# PLANT PATHOLOGY

## A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

*Published quarterly for the*
*Ministry of Agriculture, Fisheries and Food*
*Plant Pathology Laboratory*
*Harpenden, Herts*

VOLUME 7, No. 4
December 1958

*LONDON*
HER MAJESTY'S STATIONERY OFFICE
1958

# PLANT PATHOLOGY

## A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

*Published quarterly for the*
*Ministry of Agriculture, Fisheries and Food*
*Plant Pathology Laboratory*
*Harpenden, Herts*

VOLUME 7, No. 4
December 1958

*LONDON*
HER MAJESTY'S STATIONERY OFFICE
1958

Copyright © 2000 by Oxford University Press, Inc.
Published by Oxford University Press, Inc.
198 Madison Avenue, New York, New York 10016
Oxford is a registered trademark of Oxford University Press
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Oxford University Press.
Library of Congress Cataloging-in-Publication Data
Nagel, Thomas.
Secular philosophy and the religious temperament : essays 1927-2000 / Thomas Nagel.
p. cm.
Includes bibliographical references and index.
ISBN 0-19-513019-2
1. Philosophy. 2. Religion. I. Title.
B29.N34 2002
100—dc21 2001036124

## CONTENTS


*Page*

Surveys of Clover Rot with Incidental Observations on Eelworm in Clover: England and Wales, 1953–55 . . . . . 115

Seed Dressings for the Control of Wheat Bulb Fly. *R. Bardner* . . 125

Control of Cabbage Root Fly and Other Pests of Late-sown Turnips. *B. D. Moreton, W. I. St. G. Light and Margaret E. John* . . . . 130

Sugar Beet Yellows in Great Britain, 1957. *R. Hull* . . . . . 131

Angular Leaf Spot of Cucumber in England. *R. Lelliott* . . . . 132

Some Observations on the Tobacco Veinal Necrosis Strain of Potato Virus Y. *D. E. Richardson* . . . . . 133

Some Notes on the Biology of the Cabbage Gall Weevil. *R. M. Patel* . 136

The Efficiency of Certain Grasses as Hosts of Cereal Root Eelworm. *J. J. Hesling*. . . . . 141

Some Turnip Viruses in Scotland and their Effect on Yield. *R. M. Lister* . 144

Pea Midge in Yorkshire and Lancashire. *W. J. Bevan and G. Murdoch* . 147

Observations on a Race of *Ditylenchus dipsaci* attacking Annual Aster and Sweet Sultan. *E. B. Brown* . . . . . 150

New or Uncommon Plant Diseases and Pests . . . . . 152


---


Copies of *Plant Pathology* may be obtained direct or by subscription from Her Majesty's Stationery Office at any of the addresses given on the back of cover or through any bookseller. Price of single copies 5*s*. 0*d*. net (5*s*. 4*d*.); subscription rate 21*s*. 4*d*. for four issues, including postage.



Unless otherwise stated, all material in this publication is Crown Copyright, and may not be reproduced without the permission of the Controller of H.M. Stationery Office.

The Ministry accepts no responsibility for the commercial advertisements included in this publication.

In the interests of factual reporting, occasional reference in this Journal to trade names and proprietary products may be inevitable. No endorsement of named products is intended, nor is any criticism implied of similar products which are not mentioned.



Manuscripts for consideration and all correspondence on plant pathology matters should be addressed to the Editor, *Plant Pathology*, Plant Pathology Laboratory, Milton Road, Harpenden, Herts. Other editorial correspondence should be addressed to The Production Editor, *Plant Pathology*, Ministry of Agriculture, Fisheries and Food, Whitehall Place, London, S.W.1 (Tel. Trafalgar 7711).

# SURVEYS OF CLOVER ROT WITH INCIDENTAL OBSERVATIONS ON EELWORM IN CLOVER : ENGLAND AND WALES, 1953-55

*Contribution from the Conference of Plant Pathologists, National Agricultural Advisory Service, compiled by E. Lester, N.A.A.S., Shardlow (now at Reading) and E. C. Large, of the Plant Pathology Laboratory, Harpenden, Herts.*

In 1953, a survey was undertaken by the National Agricultural Advisory Service in collaboration with the Ministry's Plant Pathology Laboratory at Harpenden, to obtain information on the distribution and economic importance of clover rot, *Sclerotinia trifoliorum* Erikss., throughout England and Wales. Further objects of the survey were to distinguish, as far as possible, between losses caused by clover rot and by stem and bulb eelworm, *Ditylenchus dipsaci* (Kühn) Filipjev, and to study the incidence of clover rot in relation to cropping history and other factors.

The survey, which continued for three years, was confined to fields of broad red or late flowering red clover, either in pure stands or in ley mixtures. For the purposes of the survey each district advisory officer throughout the country was asked to select at least one and not more than six fields in his area, more or less at random from among those that he came across in the normal course of his work, and to provide preliminary information concerning each of these fields on a carefully devised record form. This called for the location of the field; its cropping history as far back as could accurately be ascertained (noting especially years when clover or beans were taken); the soil type; the state of drainage; particulars of the seed rate and mixture sown; the date of sowing, and nurse crop, if any; and the management of the field in the autumn—whether the crop was fed off, cut, or left. These forms also called for important general information on the amount of clover grown in the district, and the number of enquiries concerning trouble, of any kind, with clover crops during the previous few years. Fields which were the subject of enquiries during the season were included in the survey, but were carefully distinguished from the random fields in all the records.

The district officers' record forms were sent to the provincial plant pathologists not later than the end of February, and the plant pathologists then went out, usually in company with the district officer concerned, to make the critical assessments of the incidence of clover rot in the fields at the end of winter, generally in April. In many, but not all cases, a further inspection was made in June or early July, to ascertain the effect of the loss of stand found at end of winter on the ultimate crops.

The surveys were carried through according to plan in most counties, and on the whole on sufficient fields, whether in one county or another, to give adequate representation of each of the several advisory provinces, but as the survey maps show, there were some gaps, notably in Norfolk and Essex, where preoccupation with flood-damage and other problems made full participation in the survey impossible.

The inspections made by the plant pathologists were primarily for clover rot, and they were timed to the best advantage for that disease and not for eelworm. But eelworm symptoms were recorded, and the extent of eelworm damage was assessed in the same way as for clover rot. Most of the recorded cases of eelworm

were confirmed by the advisory entomologists who examined specimens brought back from the fields.

### METHOD OF CLOVER ROT ASSESSMENT

Much preliminary work, undertaken by members of the Disease Assessment Committee before the inauguration of the survey, showed that although counts of the numbers of healthy, partially affected and dead clover plants in square-yard or square-foot quadrats would provide a precise research method for the estimation of clover rot in any given field, this method would be altogether too time-consuming for use in a large number of fields in a national survey. To take fair account of clover rot patches, an impracticably large number of quadrat counts would often be required to assess a whole field by a random sampling plan. A method was therefore evolved whereby quadrat counts in a few typical parts of the field were used to determine the approximate density of the clover stand, and eye estimates, aided by a tabulation of the approximate proportion of the field area affected in specified ways, were relied upon to arrive at an approximate percentage figure for the loss of stand due to the disease in the field as a whole. The heads on the assessment record form employed by the plant pathologists were therefore as follows:

*OBSERVATIONS AT END OF WINTER* *Date:*

*Density of clover (all plants alive or dead) Mean per sq. yard* .. *1–4/5–20/20–50/over 50†*

*Diseases and/or pest present*

| *Clover rot only* | *Eelworm only* | *Clover rot and eelworm* |
|---|---|---|
| *Slight/Severe†* | *Slight/Severe†* | *Slight/Severe†* |

| *Proportion of field with clover rot:* | | *Proportion of field with eelworm:* | |
|---|---|---|---|
| Nil .. .. .. .. .. | * | Nil .. .. .. .. .. | * |
| Occasional single plants or small patches .. .. .. .. | * | Occasional single plants or small patches .. .. .. .. | * |
| Many single plants or small patches.. | * | Many single plants or small patches.. | * |
| Large patches over one yard diameter | * | Large patches over one yard diameter | * |

* Enter 'All', '¾', '½', '¼' etc. † Strike out what does not apply.

*Approximate overall estimate of loss of stand:*

*By clover rot .. .. per cent* *By eelworm .. .. .. per cent*

*By other causes (please specify)*

*OBSERVATIONS IN SUMMER* *Date:*

*Estimated percentage of field bare of clover .. .. .. .. ..*

*Was this loss probably due to the infection or infestation noted at the end of winter, or were there subsequent causes of loss, e.g., drought or severe Apion damage ?*

Although the eye estimation of overall loss of stand due to clover rot (or eelworm) at the end of winter was admittedly difficult, almost every observer found it possible to enter this figure after a little practice. There was reasonable agreement on test between the independent estimates of different observers on the same fields. The accuracy of the assessments was sufficient to enable the fields to be grouped into four broad categories for level of infection or infestation, as follows:

| *Nil* | *Slight* | *Moderate* | *Severe* |
|---|---|---|---|
| 0 per cent | 0·1 to 5 per cent | 6 to 24 per cent | 25 to 100 per cent |

The leading results of the surveys were therefore extracted on this basis. The second examinations made on many of the fields in June or early July showed that where the infection or infestation was "slight", it had in general

little effect on the ultimate stand. The cases of "moderate" or "severe" infection or infestation could therefore be taken as those in which substantial loss occurred.

### INCIDENCE AND LOSS OF STAND IN THE THREE YEARS

The distribution of one-year leys—which gives a good indication of the principal red clover growing areas in England and Wales—is shown in Fig. 1. This map is based on the county acreages given in the June returns for 1955. The location of the fields included in the survey, the extent to which the various regions were covered, and the level of clover rot in each of the survey fields at the end of winter (whether absent, slight, or moderate to severe) is shown in the survey maps for each of the three years (Figs. 2, 3 and 4). It is apparent from these maps that clover rot was absent in most of Wales†. The first analysis of the survey fields, according to loss of stand at the end of winter (Table 1), therefore excludes Wales and is given for England only.

TABLE 1

*Numbers of Fields Included in the Surveys, Analysed According to Loss of Stand from Clover Rot and Eelworm at End of Winter. England, 1953–55*

| Year | Total No. of Fields | Clover Rot | | | | Eelworm | | | | Eelworm plus Clover Rot |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Nil | Slight | Moderate | Severe | Nil* | Slight* | Moderate | Severe | |
| | | *0* | *<5 per cent* | *6–24 per cent* | *>24 per cent* | *0* | *<5 per cent* | *6–24 per cent* | *>24 per cent* | |
| *Numbers of fields* | | | | | | | | | | |
| 1953 | 483 | 144 | 239 | 51 | 49 | 389 | 61 | 17 | 16 | 79 |
| 1954 | 476 | 159 | 211 | 52 | 54 | 361 | 75 | 17 | 23 | 92 |
| 1955 | 390 | 192 | 162 | 25 | 11 | 328 | 43 | 8 | 11 | 47 |
| *Percentages of fields* | | | | | | | | | | |
| 1953 | 100 | 29·8 | 49·5 | 10·6 | 10·1 | 80·6 | 12·6 | 3·5 | 3·3 | 16·4 |
| 1954 | 100 | 33·5 | 44·3 | 10·9 | 11·3 | 75·8 | 15·8 | 3·6 | 4·8 | 19·3 |
| 1955 | 100 | 49·3 | 41·5 | 6·4 | 2·8 | 84·1 | 11·0 | 2·1 | 2·8 | 12·1 |

* See reservations in text.

The proportions of the crops affected to the several extents at the end of winter in each of the three years may be seen more clearly from the histograms (Fig. 5), but in comparing the incidence of eelworm with that of clover rot, it should be borne in mind that the field assessments were made in the main by plant pathologists, and that some masking of eelworm symptoms may already have occurred when the assessments were made (Anon., 1957) so that eelworm may well have been "slight", or at least present, in a higher proportion of the crops than that indicated.

The regional variation in incidence and severity of clover rot, and also of eelworm, over the three years is indicated in Table 2, which gives the percentages of the crops surveyed in each advisory region in which the disease (or pest) was present at all (irrespective of degree of attack) and also the percentages in which the damage was moderate or severe. This Table should be read in conjunction with the maps, which show the number and location of the crops included in the survey in each region.

† Of 38 fields in Wales included in the survey in 1953, and 13 in 1955, none was affected. Of 94 fields included in 1954, there were 4 cases of clover rot (1 slight, 2 moderate and 1 severe) all in Monmouth; and 7 cases of eelworm (5 slight and 2 severe) in Denbigh, Flint, Cardigan and Monmouth.

**Fig. 1.** Distribution of one-year leys (1955, sown 1954). The number of dots per county indicates acreage in county, but the position of the dots within the county boundaries is conjectural.

One of the points brought out by the surveys is that clover rot is more widely distributed in some areas than was suspected from previous records. The occurrences (all associated with four- or five-course rotations) in the Whitby area of Yorkshire, in eastern Cheshire, in parts of Durham, and some areas in the south-east (see maps) are noteworthy in this respect.

The distribution of the disease over the country as a whole reflects that of one-year leys in four- and five-course rotations (compare Figs. 1, and 2, 3, 4). It is widespread over most of England, but most prevalent and severe in parts of Yorkshire, the Midlands and eastern and south-eastern counties, where four- and five-course rotations predominate and there is much red clover in the short ley mixtures. It is rare in Northumberland, Cumberland, Wales, Devon and Cornwall, where relatively little red clover is grown, and that generally in small amounts in long-ley mixtures.

Where the disease has become established in the four- and five-course rotations, lengthening of the intervals between clover leys tends to reduce the severity of the attack by clover rot, but it does not eliminate infection.

In general the distribution of clover eelworm appears similar to that of clover rot, although numerous cases were found not only in the one-year ley areas,

Fig. 2. Location of fields included in the survey in 1953, and incidence of clover rot in these fields at the end of winter.

but also in the long-ley areas of Northumberland, Cumberland, North Wales, Devon and Cornwall. Over the three years of the survey, clover rot caused considerable (over 5 per cent) loss of stand in 242 of the 1349 crops surveyed in England, while eelworm caused a similar loss in 92 of the crops. Thus there was an indication that rather less than a third of the cases of real loss from "clover sickness" were due to eelworm and rather over two-thirds to clover rot.

Factors other than clover rot and eelworm were, however, responsible for considerable damage to clover in some areas. In the Eastern and South-eastern Provinces damage by pigeons was often more important than clover rot. In the South-eastern Province it was estimated that in more than half the fields examined in 1953 the loss from poor soil conditions and cultural practices was greater than that from clover rot and eelworm.

## EFFECT OF SEASONAL CONDITIONS

Comparison of the findings for the years of the survey with past records of the incidence of clover rot (Moore, 1943, 1948) show that in general the loss caused by the disease was about normal in 1953 and 1954, but below normal in 1955. There were, however, marked regional differences confirmed by general reports

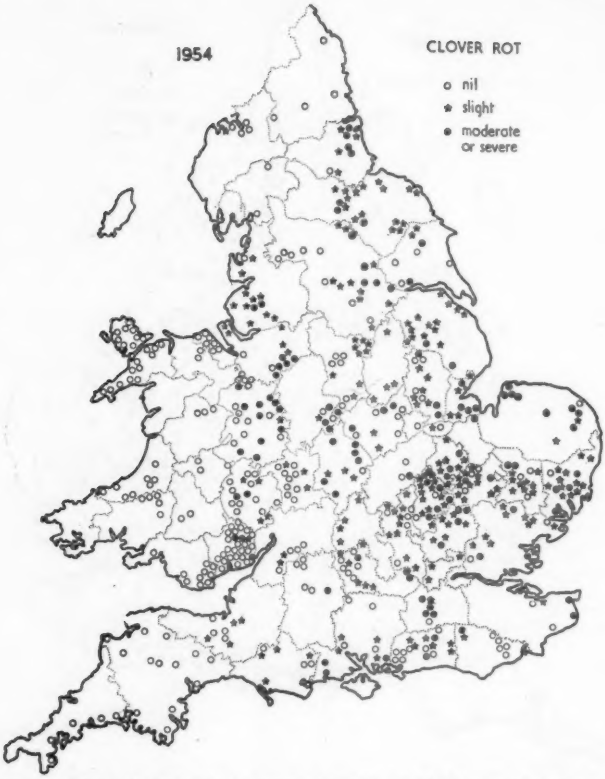



**Fig. 3. Location of fields included in the survey in 1954, and incidence of clover rot in these fields at the end of winter.**

and brought out strikingly by the survey maps. In both 1954 and 1955 the disease was less prevalent than usual in the West Midlands, and indeed over all the country south-west of a line from the Mersey to the Thames Estuary. Although the *severity* of the disease was unusually slight everywhere in the country in 1955, the proportion of the fields in which infection was *present*, at any rate in Yorkshire, the East Midlands and Eastern Provinces, did not differ greatly from that in 1953 and 1954 (Table 2).

Dillon Weston, Loveless and Taylor (1946) observed that in a mild winter following a wet autumn clover may be ruined, but in hard frosty weather it usually recovers sufficiently to yield a crop. Moore (1943, 1948) also recorded that clover rot, beginning in November or even earlier, but developing mostly in January to March, tends to become severe after a mild and wet autumn and winter.

In 1952–53, there was an unusually cold autumn with early frosts and much snow in November and December. January was cold and dry. February was dry with much snow. March was dry and sunny.

In 1953–54, there was a very mild autumn and early winter with little rain. January had a cold spell continuing into February, and March was cold with average rain.

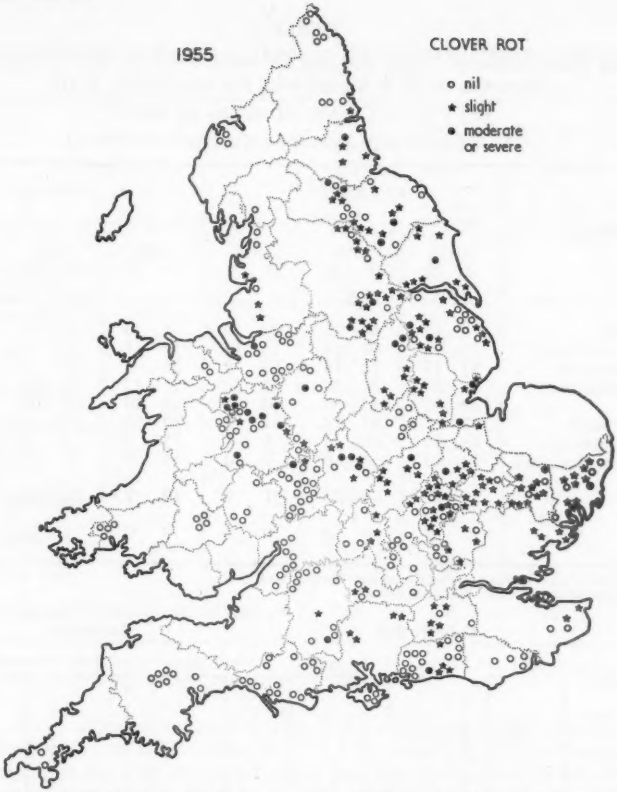



Fig. 4. Location of fields included in the survey in 1955, and incidence of clover rot in these fields at the end of winter.

In 1954–55, October was warm with average rain. November and December were mild and wet. January, February and March were all cold with much ice and snow, and normal temperatures were not reached until April.

The experience in the years of the survey confirms the checking effect of cold conditions in January, February and March on the development of clover rot. It is noteworthy that there were numerous reports of infection before Christmas in 1953, as would be expected from the very mild autumn and early winter, but with the subsequent cold spell in January and February 1954, the incidence of the disease at the end of the winter was much the same as in the previous season (Fig. 5). In 1955, there were again cold conditions in January and February, and also in March, but another factor undoubtedly contributed to the low incidence of the disease in that year. The lateness of the harvest after the wet summer of 1954, with consequent late removal of the nurse crops, made the clover late in growing away, so that the stand of clover throughout the late autumn and winter was less dense than in the two previous years.

## OTHER FACTORS AFFECTING CLOVER ROT

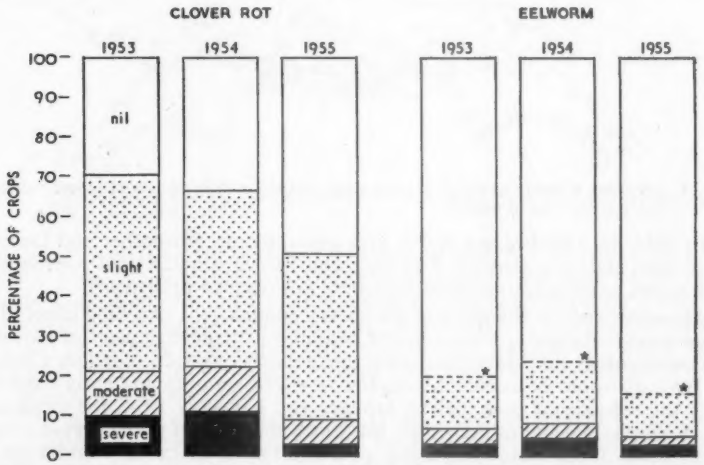
Factors about which information was obtained in the course of the surveys included: previous cropping with clover, autumn grazing or cutting, soil texture, trouble with clover in the past, drainage and density of the clover stand. Taking

TABLE 2

*Regional Distribution of Clover Rot and Eelworm, 1953–55. Percentages of Crops Surveyed in Each Region with the Disease (or Pest):*
*(P) Present (Slight, Moderate or Severe)*
*(S) Substantially Affected (Moderate or Severe)*

| Region | Clover Rot | | | | | | Eelworm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | | 1954 | | 1955 | | 1953 | | 1954 | | 1955 | |
| | *P* | *S* | *P* | *S* | *P* | *S* | *P* | *S* | *P* | *S* | *P* | *S* |
| Northern* .. .. | 17 | 12 | 40 | 20 | 29 | 6 | 1 | 0 | 50 | 20 | 12 | 0 |
| Yorks. and Lancs. | 72 | 18 | 79 | 19 | 74 | 11 | 16 | 1 | 6 | 0 | 6 | 0 |
| East Midlands .. | 83 | 15 | 72 | 16 | 67 | 9 | 25 | 7 | 27 | 3 | 30 | 4 |
| West Midlands .. | 89 | 39 | 56 | 35 | 33 | 20 | 22 | 12 | 33 | 15 | 16 | 4 |
| Eastern .. .. | 88 | 31 | 87 | 30 | 80 | 8 | 18 | 10 | 29 | 10 | 22 | 13 |
| South Eastern .. | 77 | 15 | 62 | 18 | 37 | 2 | 20 | 10 | 17 | 5 | 13 | 6 |
| South Western† .. | 45 | 15 | 41 | 4 | 6 | 3 | 35 | 7 | 15 | 4 | 9 | 0 |
| Devon and Cornwall | 14 | 10 | 0 | 0 | 0 | 0 | 14 | 0 | 22 | 17 | 0 | 0 |
| England .. .. | 70 | 21 | 67 | 22 | 51 | 9 | 19 | 7 | 24 | 8 | 16 | 5 |
| Wales .. .. | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 7 | 2 | 0 | 0 |

* Northumberland, Durham, Cumberland and Westmorland.
† Gloucestershire, Somerset, Wilts and Dorset.




* The proportion of crops in which eelworm was present may have been higher than that shown. See p. 117.

Fig. 5. Proportions of total numbers of crops in survey in which clover rot (*left*) and eelworm (*right*) were absent, slight, moderate or severe. England, 1953–55.

percentage loss of stand due to clover rot at the end of winter as a measure of the severity of attack, an analysis was made of the effect of each of these factors and is shown in Table 3. This analysis was made only on crops for which sufficiently full and trustworthy information was available; the number of crops, selected to represent the three years and also the various regions as fairly as possible, being as shown at the bottom of the Table.

TABLE 3

*Percentage of Healthy and Infected Crops in which Various Factors were Operative, 1953–55*

| Factor | Healthy crops *0* | Slightly affected crops *<5 per cent* | Moderately affected crops *6–24 per cent* | Severely affected crops *≥24* per cent* |
|---|---|---|---|---|
| Last clover crop | | | | |
| Within 5 years | 30 | 40 | 58 | 70 |
| Not within 5 years | 70 | 60 | 42 | 30 |
| Autumn treatment | | | | |
| Grazed | 62 | 28 | 27 | 36 |
| Not grazed | 38 | 72 | 73 | 64 |
| Soil type | | | | |
| Light or medium | 74 | 73 | 63 | 73 |
| Heavy | 26 | 27 | 37 | 27 |
| Clover trouble in past | | | | |
| Yes | 9 | 13 | 13 | 29 |
| No | 91 | 87 | 87 | 71 |
| Drainage | | | | |
| Poor or only fair | 23 | 25 | 39 | 12 |
| Good | 77 | 75 | 61 | 88 |
| Stand of clover† | | | | |
| Dense | 25 | 44 | 67 | 75 |
| Medium or thin | 75 | 56 | 33 | 25 |
| Numbers of crops included in above analysis | 140 | 141 | 116 | 103 |

* Loss of stand by clover rot at end of winter.

† Stand at end of winter. Dense = over 20 plants per sq. yard.

This analysis shows that the majority of the moderately and severely affected crops followed clover within the previous five years; and also that a history of clover trouble in the past was much more frequent in the severely affected crops (29 per cent) than in the healthy (9 per cent). High clover populations, as measured by density of stand at end of winter, were also much more frequent in the affected crops than in the healthy. Autumn grazing, generally accepted as a useful method of restricting the development and spread of clover rot, appears to have been beneficial (over the three years only 38 per cent of the healthy crops were not grazed, against 64 per cent in the severely affected) but there was considerable seasonal variation in the effect of grazing. It was more marked in 1953–54 than in the other two years. The data on soil type and drainage fail to reveal any clear-cut effect of these factors on clover rot, either beneficial or otherwise.

It was noted in the course of the surveys that although clover rot occurred most frequently and was most severe where the crop followed clover within the past five years, a long rotation is not sufficient to eliminate the disease entirely. There were a number of cases in which infection was present, and a few in which it was quite severe, even though no clover or beans had been taken within the previous ten years. In some areas with a history of clover rot, as for example in the East Riding of Yorkshire, there is a tendency to replace red clover by mixtures containing a substantial proportion of white clover with or without some alsike.

Of the 1494 fields included in the surveys for England and Wales as a whole during the three years, 1274 were chosen more or less at random in the various areas, and 220 or 15 per cent were the subject of advisory enquiries. There was some tendency for infection with clover rot or infestation with eelworm to be

higher in the fields about which there were enquiries, but as many of these concerned troubles due to acid conditions, faults in management and the like, the inclusion of these fields did not materially affect the representation of the clover acreage in the surveys, which was as shown in the survey maps.


## SUMMARY

In surveys conducted in England and Wales in each of the years 1953, 1954 and 1955, little clover rot was found in Wales, and that only in Monmouthshire. In England, clover rot was found to be *present* in about 70 per cent of the fields examined in 1953 and 1954, when the incidence of the disease was about normal, and in about 50 per cent of the fields in 1955 when it was below normal. In 1953 and 1954, the loss of stand due to clover rot at the end of winter was between 6 and 24 per cent in about 10 per cent of the crops, and over 24 per cent in a further 10 per cent. In 1955 the losses were only about half as great. Cases of the disease were found to be most frequent and severe in parts of England where four- or five-course rotation is practised and one-year leys containing much red clover are the rule. In Wales, Cumberland, Northumberland, Devon and Cornwall, where one-year leys are few, and only a small proportion of red clover is used in the long-ley mixtures, the disease is rare. Grazing or cutting in autumn was found to have some beneficial effect in reducing the incidence of the disease. There was no clear indication of influence by soil type or drainage. The survey was primarily for clover rot, but in the course of the work the presence of eelworm was recorded in about 20 per cent of the fields, and moderate or severe loss of stand due to this cause was found in about 7 per cent of the fields each year.


The Conference of Plant Pathologists takes this opportunity of thanking all the district advisory officers and farmers who took part in this work, and also of thanking their colleagues in the entomology and grassland husbandry departments for their collaboration.

## REFERENCES


ANON. (1957). Stem and Bulb Eelworm on Clover. *Minist. Agric. Fish. Lond., Advisory Leaflet* No. 409.

DILLON WESTON, W. A. R., LOVELESS, A. R. and TAYLOR, R. ERIC. (1946). Clover Rot. *J. agric. Sci.*, **36**, 18–28.

MOORE, W. C. (1943). Report on Fungus, Bacterial and other Diseases of Crops in England and Wales for the Years 1933–42. *Bull. Minist. Agric. Fish., Lond.*, No. 126.

MOORE, W. C. (1948). Report on Fungus, Bacterial and other Diseases of Crops in England and Wales for the Years 1943–46. *Bull. Minist. Agric. Fish., Lond.*, No. 139.

# SEED DRESSINGS FOR THE CONTROL OF WHEAT BULB FLY

*by* R. BARDNER

*Rothamsted Experimental Station, Harpenden, Herts*

RECENT research into methods of controlling the larvae of wheat bulb fly, *Leptohylemyia coarctata* (Fall.), necessitated the development of a simple method of comparing a large number of insecticides as a preliminary to more rigorous field tests of a few selected treatments. This paper reports the results of two seasons' work in which twenty-seven different insecticides were tested as seed dressings. The materials used were: aldrin (recrystallized), barium silicofluoride (pure), *gamma*-BHC (pure), calcium arsenate (As content 21·9 per cent by weight), chlordane (90 per cent active ingredient), chlorothion (technical), DDT (recrystallized), demeton (50 per cent active ingredient, 50 per cent wetter), diazinon (pure), dieldrin (recrystallized), "dipterex" (98 per cent), endrin (recrystallized), fluoroacetanilide (technical), heptachlor (recrystallized), isodrin (recrystallized), lead arsenate (pure), "lethane" (10 per cent), malathion (97 per cent), methoxychlor (technical), demeton-methyl (50 per cent active ingredient, 50 per cent wetter), paraoxon (pure), parathion (99 per cent), "pyrolan" (pure), sodium fluoroacetate (90 per cent), "thimet" (90 per cent), toxaphene (technical), zinc fluoroarsenate (As content 19·5 per cent by weight).

Each insecticide was tested at two of three possible levels of application, respectively 1, 0·15, and 0·04 per cent by weight of insecticide to weight of seed. The two higher rates of 1 per cent and 0·15 per cent were used unless phytotoxicity was noticed at either of these levels in preliminary germination tests (not described here). When this occurred the two lower rates of 0·15 per cent and 0·04 per cent were used, though some materials were tested at only the lowest rate. Table 1 gives various equivalents of the seed rates used, in lb per acre, oz per bushel and percentage weight of seed.

TABLE 1

*Equivalents of Various Rates of Application of Seed Dressings*

(One bushel of wheat weighs approximately 64 lb)

| Amount of Insecticide as a Percentage of the Weight of the Seed | Application Rate in Ounces per Bushel of Dressings with Different Percentages of Insecticide | | | | Pounds of Insecticide per acre (Assuming Seed Rate of 3 Bushels of Wheat per acre) |
|---|---|---|---|---|---|
| | *70 per cent* | *60 per cent* | *40 per cent* | *20 per cent* | |
| 1 | 14·6 | 17·1 | 25·6 | 51·2 | 1·92 |
| 0·15 | 2·2 | 2·6 | 3·8 | 7·7 | 0·29 |
| 0·04 | 0·6 | 0·7 | 1·0 | 2·0 | 0·08 |

When calculating the amount of active ingredient to be used to the weight of the seed, usually no allowance was made for impurities. For example, the same weights of the "dipterex" formulation (98 per cent pure) and of the aldrin formulation (recrystallized) were used for 0·15 per cent seed dressings. Exceptions to this were "lethane", demeton and demeton-methyl, which were only available in dilute concentration.



(74463) A**

All the insecticides were formulated with an inert siliceous earth diluent. This material had a mean particle size of 9$\mu$ and the largest particles could pass through a 200 mesh sieve. In formulation, insecticides were ground up with the filler using a pestle and mortar. Acetone was added to formulations containing a solid insecticide and evaporated off during the grinding process, producing an intimate mixture of insecticide and filler.

The 1 per cent rate is considerably higher than the 0·08–0·04 per cent rate usually employed for insecticide dressings on cereals. At this high rate of active ingredient not all of the particles of a dry dressing will adhere to the seed. To overcome this difficulty the seed was treated with an aqueous solution of an adhesive agent before the insecticide formulations were added. For the sake of uniformity this method was also used for all treatments at the two lower rates of 0·15 per cent and 0·04 per cent weight of insecticide to weight of seed.

Seed was treated in fifty-gramme lots, in a container made by sealing two cut-down boiling tubes together with adhesive tape to form a cylinder 1½ inches in diameter by 6 inches long, both ends of which were rounded. This type of vessel has no "blind spots" in which insecticide can collect. Using this container, which was shaken by hand, the seed was mixed with 0·1g of a dry dressing containing an organo-mercurial fungicide. The seed in the container was next shaken with 3 ml of 3 per cent solution of a sticking agent (methyl cellulose, 10–15 cp viscosity grade). When the seeds were moistened thoroughly the seed dressing was added. After further shaking, the seeds were spread out to dry on filter papers at room temperature. Although this method produced increased seed moisture content, germination was not impaired.

Tests using diluent as a dressing, without insecticide, showed that some of the material adhered to the walls of the tube. The amount retained in this way varied from 2·5 per cent at the lowest rate used to 7·5 per cent at the highest rate, the percentage lost being directly related to the weight of dressing applied.

## TESTS OF EFFECTIVENESS

A modification of an unpublished method devised by M. J. Way was used. Forty treated wheat seeds were sown in late November in two parallel rows 1½ inches deep in a seed box measuring 8 × 12 × 4½ inches filled with sterilized potting compost. The rows were 4 inches apart, and each treatment was replicated three times. After planting, the boxes were arranged in random order embedded in ashes in a sheltered garden.

Wheat bulb fly eggs were obtained from flies kept in the laboratory, as described by Bardner and Kenten (1957). The eggs were examined for fertility and in late December or early January, were inserted in a line midway between the rows of wheat seeds and to the same depth. This was before the earliest possible hatching date of the larvae.

Plants attacked by wheat bulb fly larvae are easily recognized. When larvae hatch they bore into the base of a wheat stem (the bulb) and feed upon the lower part of the central shoot, which collapses and subsequently the whole stem is killed. Each larva is capable of attacking several stems before pupation occurs about 2½ months after hatching. Results were therefore assessed by a weekly count of freshly damaged stems, which were not removed, but marked with paint.

This method was used in two experiments:

In November 1955, all seeds were treated with the same weight of formulated material (0·714 g per 100 g), the concentration of active ingredient in the dressing being varied to get the different rates. Seeds were planted on November 23 and there were twelve eggs to each box. Cold weather delayed egg hatch and no infected stems were noticed until the middle of March. No freshly attacked stems were noticed after mid May 1956.

In November 1956, the seeds were treated with either 2·5, 0·375 or 0·1 g of a 20 per cent formulation of each active ingredient, except for "lethane" and demeton-methyl where, because of the dilute nature of the material, higher rates had to be used to apply the same amount of active ingredient per seed.

TABLE 2

*Results of the Seed Dressing Trials*

| 1955–56 | | | 1956–57 | | |
|---|---|---|---|---|---|
| Insecticide | Dressing Rate* *per cent* | Mean No. of Damaged Stems† | Insecticide | Dressing Rate* *per cent* | Mean No. of Damaged Stems† |
| *gamma*-BHC‡ .. | 0·15 | 1·3 | Heptachlor .. | 1 | 8·3 |
| Heptachlor .. | 1 | 3·0 | Dieldrin .. .. | 1 | 10·0 |
| Parathion‡ .. | 0·15 | 3·0 | Heptachlor .. | 0·15 | 11·7 |
| Heptachlor .. | 0·15 | 4·3 | Chlordane .. | 1 | 12·7 |
| Endrin .. .. | 1 | 5·0 | Dieldrin .. .. | 0·15 | 14·0 |
| Dieldrin .. .. | 0·15 | 5·3 | | | |
| Isodrin .. .. | 1 | 5·7 | Toxaphene .. | 1 | 15·0 |
| Dieldrin .. .. | 1 | 6·3 | Sodium fluoroacetate | 0·04 | 16·0 |
| Isodrin .. .. | 0·15 | 7·0 | Malathion .. | 0·15 | 16·7 |
| DDT .. .. | 0·04 | 7·0 | Lead arsenate .. | 0·15 | 16·7 |
| | | | Paraoxon‡ .. | 0·15 | 17·0 |
| Endrin .. .. | 0·15 | 7·7 | Lead arsenate .. | 1 | 17·0 |
| Aldrin .. .. | 1 | 8·0 | Thimet‡ .. .. | 0·15 | 17·0 |
| Aldrin .. .. | 0·15 | 9·0 | Methoxychlor .. | 1 | 17·3 |
| DDT .. .. | 0·15 | 9·7 | Sodium fluoroacetate | 0·15 | 17·3 |
| Parathion .. | 0·04 | 9·7 | Methoxychlor .. | 0·15 | 17·7 |
| *gamma*-BHC .. | 0·04 | 10·7 | Chlordane .. | 0·15 | 18·0 |
| Chlorothion‡ .. | 0·15 | 11·3 | Zinc fluoroarsenate | 1 | 18·0 |
| Demeton-methyl .. | 0·04 | 13·0 | Barium silicofluoride .. .. | 0·15 | 18·0 |
| Dipterex .. .. | 0·04 | 13·3 | Paraoxon‡ .. | 0·04 | 18·3 |
| Control, fungicide only .. .. | — | 13·5 | Control, no fungicide .. .. | — | 18·7 |
| Dipterex .. .. | 0·15 | 14·0 | Malathion .. | 0·04 | 19·3 |
| Diazinon .. .. | 0·04 | 14·0 | Control, fungicide only .. .. | — | 19·7 |
| Diazinon .. .. | 1 | 15·0 | Pyrolan .. .. | 0·04 | 20·0 |
| Chlorothion .. | 0·04 | 15·3 | Mercurous chloride | 0·15 | 20·0 |
| Control, no fungicide .. .. | — | 16·6 | Mercurous chloride | 1 | 20·3 |
| Demeton .. .. | 0·04 | 16·7 | Lethane .. .. | 1 | 20·3 |
| | | | Lethane .. .. | 0·15 | 21·0 |
| S.E. of mean number of damaged stems of any treatment .. | | ±1·8 | Pyrolan‡ .. .. | 0·15 | 21·7 |
| | | | Thimet .. .. | 0·04 | 21·7 |
| Least significant difference between means of any two treatments (P = 0·05) .. .. | | 5·0 | Calcium arsenate .. | 0·15 | 22·0 |
| | | | Barium silicofluoride .. .. | 1 | 22·7 |
| S.E. of mean number of damaged stems of either control .. | | ±1·25 | Fluoroacetanilide .. | 0·04 | 22·7 |
| | | | Toxaphene .. | 0·15 | 23·3 |
| Least significant difference between means of either control and any treatment (P = 0·05) | | 4·3 | Zinc fluoroarsenate | 0·15 | 23·7 |
| | | | Fluoroacetanilide‡ | 0·15 | 23·7 |
| | | | Calcium arsenate .. | 1 | 26·3 |
| | | | S.E. of mean number of damaged stems .. .. .. .. | | ±2·1 |
| | | | Least significant difference between two means (P = 0·05) | | 6·0 |

* Weight of active ingredient as percentage of weight of seed. † Mean number of damaged stems per replicate.
‡ Phytotoxic effect with this treatment.

Seeds were planted on November 26 and there were fifteen eggs to each box. Attacked stems were first noticed at the end of February, and the attack finished at the end of April 1957.

Results are set out in Table 2. In both trials most treatments germinated well, the mean rates being 97 per cent in 1955–56 and 91 per cent in 1956–57. Slight phytotoxicity was noticed in a few treatments, and variance analysis showed that significant differences existed in germination rates. Those treatments which were significantly worse than the controls are indicated in the Table.

Table 2 shows the treatments ranked in the order of protection they gave against wheat bulb fly attack in these experiments, as measured by the numbers of damaged stems. Statistical analysis showed that there were significant differences between treatments.

Two insecticides, heptachlor and dieldrin, were common to both seasons. Differences between treatments were not sufficiently great to suggest significant differences between any two adjacent treatments when ranked in order. However, treatments can be compared against a standard, and the 1 per cent heptachlor dressing was chosen for this purpose. In each half of the Table a space has been left, below which treatments had significantly more damaged stems than the 1 per cent heptachlor treatment. From this it can be seen that the following insecticides were comparable to 1 per cent heptachlor: *gamma*-BHC at 0·15 per cent, parathion at 0·15 per cent, chlordane at 1 per cent, endrin at 1 per cent, isodrin and dieldrin at both 0·15 per cent and 1 per cent and DDT at 0·04 per cent. Of these, parathion and *gamma*-BHC exhibited phytotoxic symptoms at the rates used.

It is noteworthy that in both the trials, heptachlor gave better protection than dieldrin, although the differences were not significant. Heptachlor is a constituent of chlordane which also gave good results in these trials. Following some early seedbox tests at Rothamsted (Bardner and Way, in Potter, 1956), Woods, Towler and Gough (1957) used parathion, DDT, endrin and isodrin, but found these no more effective than aldrin, dieldrin or *gamma*-BHC.

## DISCUSSION

Insecticide seed dressings for cereals were developed originally to give protection against wireworm attack. For this purpose levels of active ingredient of the order of 0·08—0·04 per cent of the weight of the seed usually give adequate protection. The weight of active ingredient per seed is between 0·04 and 0·015 mg, based on a seed weight of 54–37 mg. This is a much smaller rate per seed than that used to control the onion fly *Hylemyia antiqua* Meig., and the bean seed fly, *Hylemyia cilicrura* Rond., which are closely related to wheat bulb fly.

For *H. antiqua* attacking onion, Peterson and Noetzel (1954) used dieldrin, aldrin or heptachlor dressings at 6–10 per cent active ingredient to weight of seed. Other workers have used dieldrin at 4·5 per cent (Ehlers, 1955) and 3·25 per cent (Carden, private communication 1957). In all cases treatments gave satisfactory control until harvest.

With *H. cilicrura* attacking cotton, *cucurbitacea* or green peas Frost, Anderson and Elmore (1954) found 0·01–0·07 per cent *gamma*-BHC to weight of seed satisfactory. Miller and Dustan (1954) recommend *gamma*-BHC at 0·026 per cent or aldrin at 0·03 per cent for control of *H. cilicrura* on a variety of crops.

An onion seed weighs about 3 mg, and a 4 per cent seed dressing would contain about 0·12 mg of active ingredient per seed. Seeds of French beans, *Phaseolus vulgaris*, weigh about 540 mg, so that a 0·03 per cent dressing would contain 0·16 mg per seed. These amounts are between three and eleven times greater than the weight per seed of cereal dressings. It would seem desirable to use at least as much insecticide per seed for protection against wheat bulb fly

as is used for the other two *anthomyiid* species. To do this the dosage rate would have to be between 0·22 per cent and 0·43 per cent active ingredient to weight of seed. With seed treatments against wheat bulb fly there is also a long interval between sowing the seed and larval attack. Some inactivation of the insecticide might occur during this period so that it may be desirable to use still higher rates of insecticide, of the order of 1 per cent of the weight of the seed. For this purpose dieldrin or heptachlor, two of the most successful insecticides in these experiments, are well suited; as, unlike *gamma*-BHC, they have not shown phytotoxic effects at these levels. A disadvantage of these materials is that larvae are able to penetrate some tillers before dying, whereas *gamma*-BHC dressings, when effective, stop the larvae from entering the plant (Gough and Woods 1954).

In the experiments described in this paper, insecticides applied at 1 per cent of the weight of the seed usually did not give significantly better control than applications at the 0·15 per cent rate, but, because of the large standard error, differences would have to be very large to be significant at the 5 per cent point. In this connection the results of two field experiments are of interest. Gough and Woods (1954) found a late November sowing of seed treated with dieldrin at 0·12 per cent of the weight of the seed reduced the numbers of damaged stems by 21 per cent compared with the plants from seed treated with fungicide only. A similar dieldrin treatment sown in early January gave an 18 per cent reduction of damaged stems. Bardner and Way (in Potter, 1956) found that dieldrin at 2·25 per cent of the weight of the seed reduced the number of damaged stems by 66 per cent in a late December sowing.

## SUMMARY

None of the twenty-seven insecticides tested gave complete protection against wheat bulb fly attack. With the most successful treatments, such as dieldrin and heptachlor at 1 per cent of the weight of the seed, there were 50–70 per cent fewer damaged stems than with plants from untreated seeds, or those treated with fungicide only. Conditions in these experiments were similar to those in the field. Factors like weather or sowing date might alter the amount of protection afforded by any one insecticide, but the relative potencies of the materials tested would be approximately the same.

My thanks are due to Mr. J. A. H. Dunwoody for statistical analysis and advice, to Mr. P. Etheridge who assisted in these experiments, and to those firms who donated insecticides and other material.

## REFERENCES

BARDNER, R. and KENTEN, JOYCE (1957). Notes on the Laboratory Rearing and Biology of the Wheat Bulb Fly *Leptohylemyia coarctata* (Fall.) *Bull. ent. Res.* **48**, 821–31.

EHLERS, M. (1955). Weiteres zur Bekämfung der Zwiebelfliege. *Anz. Schadlingsk.* **28**, 57–60.

FROST, M. H., ANDERSON, L. D. and ELMORE, J. C. (1954). Effect of Certain Insecticides and Fungicides on Plant Emergence and Control of the Seed-Corn Maggot. *J. econ. Ent.* **47**, 1040–5.

GOUGH, H. C. and WOODS, A. (1954). Seed Dressings for the Control of Wheat Bulb Fly. *Nature*. **174**, 1151–3.

MILLER, L. A. and DUSTAN, A. G. (1954). Control of the Seed Corn Maggot. Publication 912, *Entomology Division, Science Service, Canada, Department of Agriculture.*

PETERSON, A. G. and NOETZEL, D. M. (1954). Seed Treatments Compared with Other Methods for Controlling the Onion Maggot. *J. econ. Ent.* **47**, 852–9.

POTTER, C. (1956). Insecticides and Fungicides Department, *Rothamsted Exp. Sta. Report for 1955.*

WOODS, A., TOWLER, M. J. and GOUGH, H. C. (1957). Field Experiments on Chemical Control of Wheat Bulb Fly. *Ann. appl. Biol.*, **45**, 388–9.

# CONTROL OF CABBAGE ROOT FLY AND OTHER PESTS OF LATE-SOWN TURNIPS

*By* B. D. MORETON, W. I. ST. G. LIGHT *and* MARGARET E. JOHN
*National Agricultural Advisory Service, Wye, Kent*

IN some years considerable loss of white turnips, broadcast in July for lifting in November, occurs in the Borough Green area of Kent, due to cabbage root fly, *Erioischia brassicae* Bouché, damaging the bulb, and to a soft rot of the crown. Experiments were begun in 1956 to find a suitable control for the root fly, and to see if this would reduce the incidence of crown rot. Dieldrin sprays were applied in September when the turnip crown was about the thickness of a pencil, and a significant reduction of damage, and some reduction of rot, was obtained with 0·1 per cent dieldrin at 100 gallons per acre. Dieldrin at 0·05 per cent in 100 gallons of water gave a slightly, though not significantly, lower degree of control. A second spray fourteen days after the first did not improve the control with either rate, and sprays at the same strengths at 50 gallons per acre were less effective. The 0·1 per cent spray also reduced the incidence of turnip gall weevil.

In 1957 the following treatments, and untreated controls, were replicated four times in randomized blocks of 3 by 3 yd plots of Model White turnips broadcast at 4 lb seed per acre on August 21 for lifting in mid-December:

A. Aldrin dust (1½ per cent) at 2 cwt per acre raked into the plots on August 19.
B. Seed dressed with 75 per cent *gamma*-BHC and 10 per cent thiram at 1 oz per lb.
C. Seed dressed with 75 per cent dieldrin and 10 per cent thiram at 1 oz per lb.
D. Dieldrin spray, 0·1 per cent applied at the rate of 100 gallons per acre on October 3 when the crowns were about pencil thickness.

Due to the late sowing yields were low, the average of turnips over 10 g in weight being only 42¾ cwt per acre. Bulbs had been attacked by larvae of cabbage stem flea beetle and turnip mud beetle besides those of cabbage root fly. It was impossible to distinguish these three types of damage with certainty, and so the total numbers of turnips over 10 g with bulbs damaged by insects were counted. The weights of clean turnips over 10 g were also recorded. Insufficient crown rot occurred to be worth recording. The results are given in the Table.

*Effect of Treatments on Yield and Percentage of Turnips Damaged*

| Treatment | Yield of Clean Turnips *cwt per acre* | Percentage Damaged by Insects | |
|---|---|---|---|
| | | *Actual* | *After Angular Transformation* |
| Aldrin soil dressing (A) .. .. | 9·6 | 72·1 | 58·1 |
| *Gamma*-BHC seed dressing (B) .. | 18·2 | 54·2 | 47·4 |
| Dieldrin seed dressing (C) .. .. | 10·8 | 66·9 | 54·9 |
| Dieldrin spray (D) .. .. .. | 31·9 | 31·6 | 34·2 |
| Control .. .. .. .. | 8·7 | 74·5 | 59·7 |
| Significant Difference | | | |
| (p = 0·05 ) .. .. .. | 7·4 | | 9·3 |
| (p = 0·001) .. .. .. | 14·0 | | 17·7 |

The 0·1 per cent dieldrin spray gave the best yield of clean turnips and the greatest reduction of pest damage; the BHC seed dressing gave a much lower degree of control, while the aldrin soil treatment and the dieldrin seed dressing were virtually ineffective.

# SUGAR BEET YELLOWS IN GREAT BRITAIN, 1957

*by* R. HULL

*Rothamsted Field Station, Dunholme, Lincoln*

YELLOWS developed exceptionally early in sugar beet crops in 1957 and caused large losses of yield. In 148 fields sampled by the agricultural staff of the British Sugar Corporation, an average of 2·2, 23·6, 42·5 and 56·8 per cent of plants had yellows at the end of June, July, August and September respectively. All the plants in occasional fields were infected by the end of June and other crops turned yellow suddenly in July. The percentage of the entire crop of 405,400 acres with under 1 per cent infection at the end of August was 10·8; with 1–20 per cent, 24·7; with 21–60 per cent, 26·7; and with over 60 per cent, 37·8. This contrasts with 1956, when only 0·2 per cent of the crop had more than 60 per cent of infected plants.

The earliest and largest outbreaks were in Kent, Sussex, Essex, Suffolk, Cambridgeshire and South Norfolk, where an average of 75 per cent of plants had yellows by the end of August. In Lincolnshire, the Midlands and the west, Yorkshire and Scotland most crops had less than 20 per cent of plants infected.

Yellows caused the following calculated losses in 1957 (cf. Hull, *Plant Pathology*, 1953, **2**, 39–43; 1954, **3**, 130; 1955, **4**, 134; 1956, **5**, 130; 1957, **6**, 131):

| Calculated Loss of Sugar | Percentage Yield | Actual Yield per Acre Sugar | Roots* | Estimated Potential Yield of Roots per Acre* | Estimated Loss of Root Yield* |
|---|---|---|---|---|---|
| A† | C† | *tons* | *tons* | *tons* | *tons* (000) |
| 19·3 | 23·6 | 1·71 | 10·7 | 13·3 | 1,039 |

* Converted to equivalents at a sugar content of 16 per cent.

†A: Assuming 4½ per cent loss for each week the plants show symptoms. C: Assuming 2·4 per cent loss for each 10 per cent infected plants at the end of August.

Sugar beet grew slowly in the cold, dry spring, but quickly in summer and autumn as a result of an unusual combination of high soil temperature in early summer and adequate rain throughout the summer and autumn. Crops in the Midlands, north and west gave heavy yields, whereas the yellows-infected crops in the south-east were unable to take advantage of the favourable growing period and gave poor yields. The estimated potential yield, had the crop been free from yellows, of 13·3 tons per acre of roots, has been exceeded only in 1950 and 1953, and the calculated loss of root yield exceeds the previous highest of 944,000 tons in 1949.

The severe attack of yellows followed the early and heavy infestation of crops by green aphids (*Myzus persicae* and *Myzus ascalonicus*) which had lived through the mild winter on weeds and brassica crops. In the sample fields there were, on average, 26·8 and 8·8 green aphids per twenty plants at the end of May and June respectively; the previous maximum at the end of May was 1·5 green aphids per twenty plants in 1949; in most years beet are uninfested at this time. That aphids should have introduced and spread yellows so extensively and so early in the south-east is probably, at least in part, a sequel to the prevalence of the disease in that area in 1956. Spraying 13,500 acres in May and 67,000 acres in June with systemic insecticide decreased the losses caused by yellows, but spraying later was ineffective.

# ANGULAR LEAF SPOT OF CUCUMBER IN ENGLAND

*by* R. A. LELLIOTT

*Plant Pathology Laboratory, Harpenden, Herts*

ANGULAR leaf spot of cucumbers is widely distributed in the U.S.A., Canada and Europe (Elliott, 1951) but there appears to be no record that the pathogen, *Pseudomonas lacrymans* (Smith & Bryan) Carsner, has ever been isolated and identified in culture in the United Kingdom. Ogilvie (1954) states that the disease is sometimes seen in this country and it was said to have existed here in 1923 (Bewley, 1923). Moore (1948) reported a suspected outbreak in 1943 at Solihull, Warwickshire, and commented on the lack of any confirmed records.

In September 1957, frame-grown cucumbers from Swavesey, Cambridgeshire, submitted to this laboratory for diagnosis, showed symptoms closely resembling those of angular leaf spot as described by Burger (1914) and Hellmers (1950). Ten isolates of a *Pseudomonas* species, all of identical colony morphology, were readily obtained in pure culture from lesions on the fruit, leaves and stems.

Two of these isolates were used in inoculation experiments. Cucumber fruits, after surface sterilization, were inoculated by pricking through a drop of bacterial suspension, and incubated at 27°C in moist chambers. Both exudates excited the translucent gummy exudate (Plate I, 1) described by Smith and Bryan (1915). In further tests cucumber seeds were immersed for ten minutes in a water suspension of the bacterium, air-dried and sown in individual pots. All of the forty-eight plants grown from inoculated seed (and none of the twenty-four controls) became infected. Thirteen plants died shortly after emergence, twenty-nine developed lesions on the cotyledons (Plate I, 1) which became extensive, invaded the stems and killed the plants, and the remaining six, which were stunted and chlorotic, died shortly after producing their first true leaves. Angular water-soaked lesions were produced on the leaves of young plants after their leaves had been rubbed with water suspensions of both isolates. In all three types of inoculation test the controls remained healthy and the isolates were recovered from infected fruits, cotyledons and leaves.

A detailed study was made of the morphological, cultural, biochemical and physiological characters of the two isolates and two reisolates, and also American and Danish strains of *Ps. lacrymans*. Only very minor differences were found between the strains, and they all agreed closely with the published descriptions of the organism. Antisera prepared in rabbits against one Danish and one English isolate cross-agglutinated to titre, and no antigenic differences between the two isolates could be detected by mirror adsorption tests.

## REFERENCES

BEWLEY, W. F. (1923). *Diseases of Glasshouse Plants*. Benn, London, 126.

BURGER, O. F. (1914). Cucumber Rot. *Bull. Fla. agric. Exp. Sta.* No. 121, 97–109.

ELLIOTT, C. (1951). *Manual of Bacterial Plant Pathogens. Chronica Botanica*. Waltham Mass. U.S.A. 67.

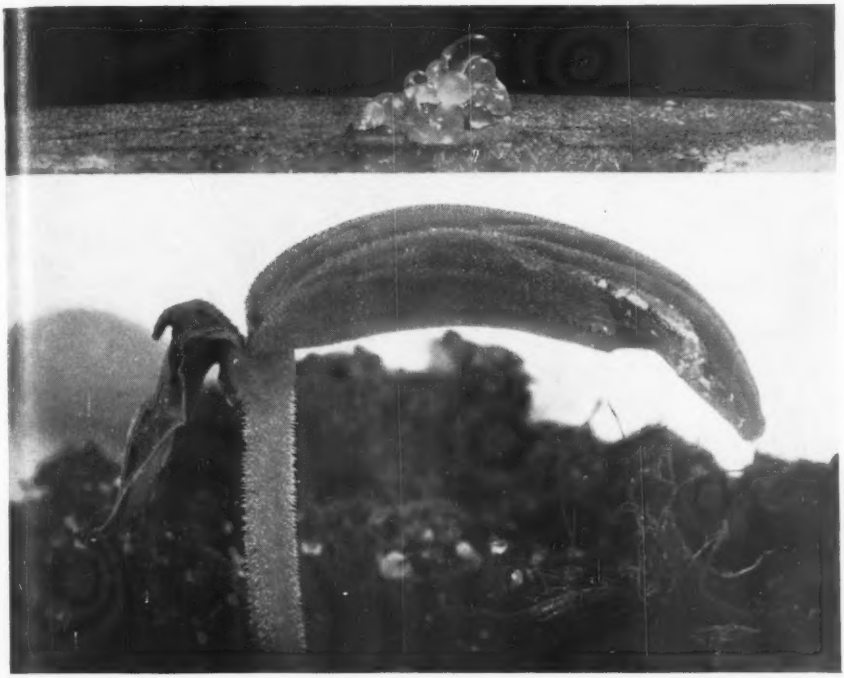
HELLMERS, E. (1950). Angular Leaf Spot of Cucumbers (*Pseudomonas lacrymans* (Smith & Bryan) Carsner) in Denmark. *Trans. Danish Acad. tech. Sci.*, **9**, 28.

MOORE, W. C. (1948). Report on Fungus, Bacterial and other Diseases of crops in England and Wales for the Years 1943–46. *Bull. Minist. Agric. Lond.*, No. 139, 46.

OGILVIE, L. (1954). Diseases of Vegetables. *Bull. Minist. Agric. Fish., Lond.*, No. 123, 52.

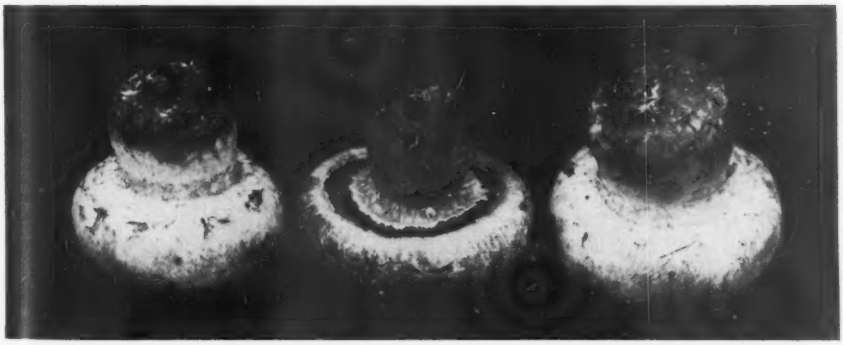
SMITH, ERWIN F. and BRYAN, MARY K. (1915). Angular Leaf-Spot of Cucumbers *J. agric. Res.*, **5**, 465–76.

## ANGULAR LEAF SPOT OF CUCUMBER



1. Cucumber seedling from inoculated seed, showing necrosis of the cotyledons and invasion of growing point. × 2. *Above:* Exudation on surface of fruit 36 hours after needle-point inoculation. Incubation temperature 27°C × 3.

## DAMAGE TO MUSHROOMS BY TARSONEMID MITES (see p. 152)



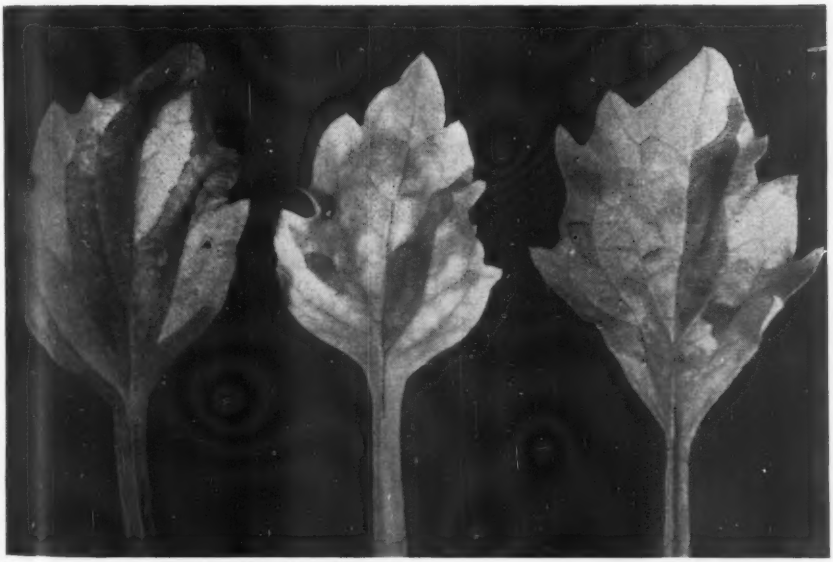
2. Affected mushrooms, showing browning at bases of stipes.

PLATE I

Annual aster plant attacked by stem eelworm, *Ditylenchus dipsaci*.

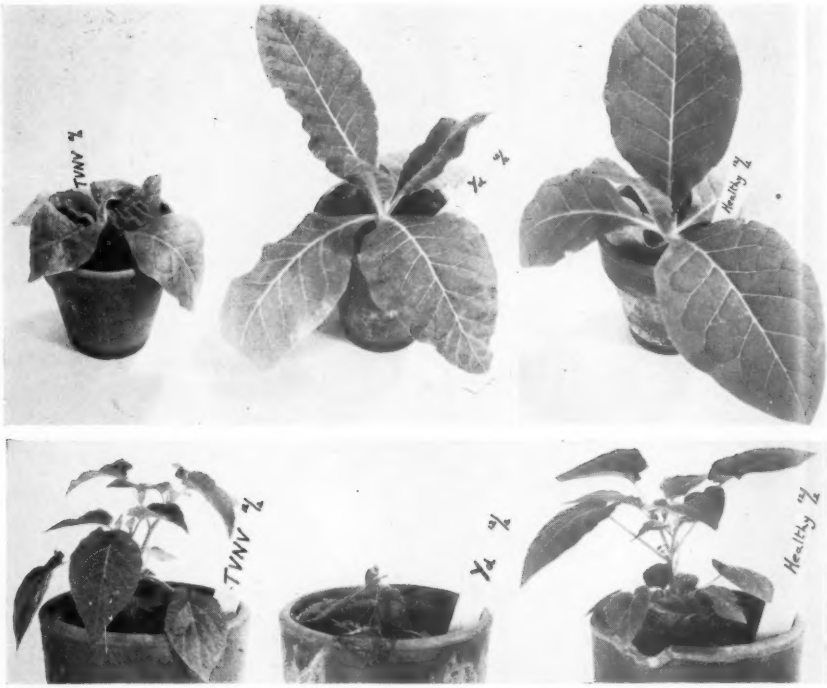
PLATE II

1. Sweet sultan damaged by *Ditylenchus dipsaci*. Healthy flower stem on right.



2. Interveinal necrosis caused by *Ditylenchus dipsaci* in leaves of annual aster.

PLATE III




1. White Burley tobacco (*above*) and *Physalis floridana* (*below*) two weeks after inoculation, (*left*) with TVNV and (*centre*) with a typical strain of virus Y; (*right*) healthy control.

*Photos: National Institute of Agricultural Botany*

2. Interference test on *Physalis floridana*. (*Right*) Plant inoculated with Yb strain of virus Y on February 21; (*left*) plant inoculated with Ye strain on March 1, and (*centre*) plant which received both inoculations, showing absence of protection by Yb against Ye. Photograph taken on March 21.

# SOME OBSERVATIONS ON THE TOBACCO VEINAL NECROSIS STRAIN OF POTATO VIRUS Y

*by* D. E. RICHARDSON

*National Institute of Agricultural Botany, Cambridge*

SMITH and Dennis (1940) isolated a virus from a tobacco plant growing near experimental potato plots in 1935. It produced necrotic symptoms on tobacco and they considered it to be a variant of virus Y. This virus was named tobacco veinal necrosis virus (TVNV) and was later shown to be serologically related to other strains of virus Y, though it did not protect plants against them (Bawden and Kassanis, 1951). Most described strains of virus Y produce vein-banding symptoms on tobacco, and these strains will be referred to as "typical" strains.

The TVNV used in this work was isolated from a commercial crop of Craigs Royal potatoes growing near Cambridge in 1954. It was isolated as a mixture with a typical strain of virus Y. Separation of the two viruses was made by transferring single aphids, fed for less than one minute, from infected to healthy tobacco plants. The necrosis which this TVNV produced on White Burley tobacco (Plate IV, 1) was similar to that described by Smith and Dennis (1940) and Bawden and Kassanis (1951). The latter authors suggested that since these symptoms in tobacco resemble those produced by a mixture of potato virus X and a typical strain of virus Y, TVNV may be more widespread than records of its occurrence suggest.

## RELATIONSHIP OF TVNV TO VIRUS Y

*Serological Test:* clarified sap from tobacco plants infected with TVNV gave a specific precipitate when mixed with antiserum prepared against virus Y.

*Interference Tests:* six typical strains of virus Y were isolated from naturally infected potatoes and named Ya, Yb, Yc (virus C), Yd, Ye, Yf. All these strains produced varying degrees of necrosis and stunting on *Physalis floridana* (Plate IV, 1), excepting Yb which resembled TVNV in that symptoms on this plant were mild and non-necrotic.

Tobacco plants infected with Yb, Yd, and Yc showed no protection against invasion by TVNV. Ya caused a delay of from two to ten days in the appearance of necrotic symptoms in comparisons with previously uninoculated controls. It was rare for any plant infected with these four strains not to become invaded with TVNV. In contrast, Ye and Yf showed a strong tendency to protect against TVNV, in that more than half the number of plants inoculated failed to become invaded.

*Physalis floridana* infected with TVNV was not protected against Ye and Yf, but there was sometimes a delay of up to two weeks in the appearance of necrosis caused by Ya, Yc and Yd in comparisons with uninoculated controls. Yb was excluded from this group of tests as symptoms on *Physalis* were non-necrotic and resembled those of TVNV.

The potato varieties Edgcote Purple and International Kidney containing virus C, were both strongly protected against invasion by TVNV. In five plants of each variety TVNV was recovered in only one plant of International Kidney one month after inoculation; a control group of five plants of International Kidney which did not contain virus C all became infected with TVNV.

A study was made of interference between typical strains of virus Y in *Physalis floridana*. Strains Yc, Yd, Ye and Yf all invaded plants previously infected with Yb (the mild non-necrotic strain) and produced necrotic symptoms at the same time as on healthy control plants (Plate IV, 2). However, Yb gave complete protection against Ya. Similar results were obtained with tobacco plants infected with Yb; invasion by the second strain of Y was demonstrated by testing for necrotic symptoms on *Physalis floridana*. From these experiments it is evident that if cross protection is to be used as a criterion for relating TVNV to virus Y, the lack of protection cannot be considered an indication of non-relationship.

The varieties Arran Pilot, Arran Viking, Craigs Alliance, Craigs Royal, Doon Star, Dr. McIntosh, Home Guard, King Edward, Majestic, Ulster Chieftain, Ulster Dale, Ulster Premier, Ulster Prince and Ulster Supreme were infected with TVNV by inoculation with sap. Only two varieties, namely Ulster Prince and Ulster Premier, gave necrotic symptoms resembling infection by a typical strain of virus Y. The remainder gave no symptoms, or only slight mottles which would be difficult to detect in the field.

## CONTROLLED TRANSMISSION EXPERIMENTS

TVNV and a typical strain of virus Y were transmitted separately to two similar batches of plants on three occasions. Two viruliferous aphids *Myzus persicae* (Sulz.) were placed on each plant according to the method described by Bawden and Kassanis (1946). A summary of the results was as follows:

| | | No. of Plants Treated with Each Virus | Percentage of Plants Infected | |
|---|---|---|---|---|
| | | | *TVNV* | *Typical Y* |
| Tobacco: | White Burley .. .. .. | 60 | 81 | 64 |
| Potato: | Arran Pilot .. .. .. .. | 60 | 79 | 55 |
| | Craigs Royal .. .. .. | 40 | 60 | 40 |
| | Ulster Supreme .. .. .. | 60 | 35 | 33 |
| | Majestic .. .. .. .. | 40 | 20 | 15 |

TVNV was transmitted more frequently than the typical strain. The order of susceptibility of the different potato varieties was the same for both strains, and followed the same order of susceptibility to typical strains of virus Y observed in the field—with the exception of Ulster Supreme, which was rarely found to be infected with virus Y under field conditions.

In this series of tests the typical strain produced severe symptoms on all varieties and there was a marked reduction in yield of tubers compared with that of the plants infected with TVNV. Yields from the latter were similar to those from the plants which remained healthy.

Aphids were given short feeds on tobacco plants which had been inoculated with a mixture of TVNV and a typical strain of virus Y two weeks earlier. The aphids were then transferred singly to young tobacco plants and it was found that the typical strain was transmitted more frequently than TVNV; in one such experiment thirty plants became infected with the typical strain, seven with TVNV and in another case nine out of ten plants became infected with the typical strain only. This suggests that the aphids preferred to feed at sites where the typical strain is localized, or that the typical strain is more readily available to the aphids when both strains are present in the same plant.

## TRANSMISSION OF TVNV IN THE FIELD

The crop of Craigs Royal in which the original isolate of TVNV was found was showing abundant spread of a typical strain of virus Y, producing severe leaf drop streak symptoms. A sample of one hundred tubers were grown on and tested. Only one plant was found to be infected with TVNV and ninety-one with the typical strain.

In 1957, ten plants in a plot of Craigs Royal were inoculated with TVNV shortly after emergence. Owing to the exceptional number of aphids early in the season, and the proximity of other virus-infected potatoes, the plot became almost completely infected with a typical strain of virus Y. The ten inoculated plants also became infected with the typical strain, and it was found that only three of these plants became systemically infected with TVNV in the foliage. Tubers were saved from these three plants and also from the plants surrounding them. TVNV was recovered in the progeny of only one of the three plants originally infected. All the others contained the typical strain of virus Y.

## Discussion

Bawden and Kassanis (1951) suggested that virus Y might interfere with the multiplication of TVNV in potato plants, as was probably the case with the strain associated with TVNV described by Smith and Dennis (1940). Munro (1955) and Klinkowski and Schmelzer (1957) found that some strains of virus Y protected against TVNV to varying extents in tobacco. A similar kind of behaviour was found in the interference tests carried out in this work, but strains Ye and Yf, which protected strongly against TVNV in tobacco, readily invaded *Physalis* plants infected with TVNV. The irregular behaviour of TVNV in interference tests with other strains of virus Y was not unique, since it was shown that a strain Yb failed to protect against invasion by some other typical strains of virus Y. The TVNV described by Munro (1955) caused very necrotic symptoms on *Physalis floridana* which suggests that another strain of Y may have been mixed with this TVNV isolate, as in the original isolate described in this paper. On the other hand, different strains of TVNV probably exist as indicated by Silberschmidt, Rostom and Ulson (1954), Klinkowski and Schmelzer (1957) and Bartels (1957).

## Summary

In contrast to most strains of virus Y, tobacco veinal necrosis virus (TVNV) usually produces only mild symptoms on potatoes and on *Physalis floridana*. In controlled transmission experiments, potato varieties were infected with TVNV as readily as with typical strains of virus Y. There was, however, some evidence that TVNV might not easily be transmitted in the field by aphids from potato plants also infected with a typical strain of virus Y. It therefore seems unlikely that TVNV could reach an epidemic level in potatoes growing in areas where typical strains of virus Y are common.

Thanks are due to Miss J. V. Ives of the N.A.A.S. Cambridge for providing the material from which the virus was isolated; to Mr. A. D. Thomson of the Molteno Institute, Cambridge, for criticism of the script; and to Mr. A. J. Gibbs of Rothamsted for carrying out the serological tests. The photographs were taken by Mr. M. W. Jolley.

## References

Bartels, R. (1957). Serologische Differenzierungsversuche mit Stämmen des Kartoffel-Y-Virus. *Third Conference on Potato Virus Diseases, Lisse-Wageningen.*

Bawden, F. C. and Kassanis, B. (1946). Varietal Differences in Susceptibility to Potato Virus *Y*. *Ann. appl. Biol.*, **33**, 46–50.

Bawden, F. C. and Kassanis, B. (1951). Serologically Related Strains of Potato Virus *Y* that are not Mutually Antagonistic in Plants. *Ann. appl. Biol.*, **38**, 402–10.

Klinkowski, M. and Schmelzer, K. (1957). Beiträge zur Kenntnis der Virus der Tabak-Rippenbräune. *Phytopath. Z.*, **28**, 285–306.

Munro, J. (1955). The Reactions of Certain Solanaceous Species to Strains of Potato Virus *Y*. *Canad. J. Bot.*, **33**, 355–61.

Silberschmidt, K., Rostom, E. and Mattos Ulson, C. (1954). A Strain of Potato Virus *Y* Inducing Local and Systemic Necrotic Spots on Leaves of Tobacco White Burley. *Amer. Potato J.*, **31**, 213–7.

Smith, Kenneth M. and Dennis, R. W. G. (1940). Some Notes on a Suspected Variant of *Solanum Virus 2* (Potato virus *Y*). *Ann. appl. Biol.*, **27**, 65–70.

# SOME NOTES ON THE BIOLOGY OF THE CABBAGE GALL WEEVIL

*by* R. M. PATEL

*Crop Protection Officer, Ahmednagar, Bombay State, India**

THE larval stage of *Ceuthorhynchus pleurostigma* Marsh commonly causes galls on the roots of crucifers. Isaac (1923a, b, c) dealt in detail with the life history and larval anatomy. Madle (1935) studied the weevil in Germany, describing the life history and crop infestation over a period of four months. The work described in this paper consists of preliminary observations and experiments on gall formation, flight, host range and host preferences.

## THE FORMATION OF GALLS

According to Imms (1947) many theories have been advanced to account for the formation of galls, but the matter is still unexplained. Attempts to produce galls artificially have, so far, mainly failed.

Experiments on gall formation were done on potted plants during the winter to find whether the gall is formed as a result of the growth of the larva. Larvae of various instars were introduced by making cavities with a small cork borer in the stems of sound plants, both above and below ground level. After the introduction of the larvae, the cavities were closed with a plug of plant tissue removed by the cork borer. Observations were made at fortnightly intervals by examining two plants each time to see if there was any gall formation. The pots containing the plants were kept outdoors, where the average monthly temperature during the period of the experiment varied from 39·3° to 59·4°F. maximum and from 31·1° to 44·3°F. minimum.

The artificial introduction of larvae did not produce galls even in the instances where the larvae remained alive in the cavities for a long time (up to ninety-six days) and reached higher instars.

A further experiment on gall formation was carried out during the summer using cabbage and charlock seedlings. Six treatments were given, about five plants being treated in each case and kept in a cage to prevent infestation from outside. Two plants were examined from each treatment at about fortnightly intervals. No galls were formed when eggs were removed from the stem at ground level; when they were introduced and failed to hatch; when larvae of the first instar were introduced and continued their growth at least for a time; nor when particles of silica were introduced. Galls did form, however, when eggs were allowed to develop normally and, in some instances, when larvae of the first instar were removed. From this it is inferred that when the egg hatches something induces gall formation, but clearly more work is required to prove this suggestion.

The relationship between gall-size and larval growth was worked out by measuring the size of galls and size of the head capsules of larvae contained by them. Only the measurements of single galls containing single larvae were taken into account. The results, plotted in Fig. 1, show that gall size increases steadily as the larva passes through successive instars. When a function of the volume of the gall (the cube of the mean diameter) is plotted against the larval instar contained, a straight line is obtained.

In the sound plants, all the tissues including vascular bundles were intact, and in the galled plants the phloem was disorganized and the effect of disorgani-

* The work described was done at the School of Agriculture, Cambridge.

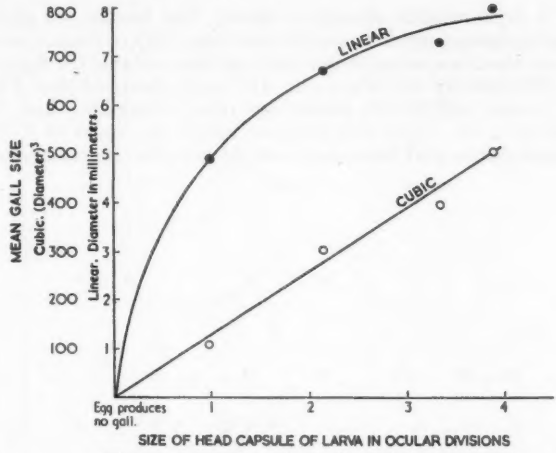



Fig. 1. Correlation of gall size with larval growth.

zation had, at certain points, passed beyond the cambium and even reached the xylem.

## FLIGHT

There is little information on flight in the literature. In order to determine whether the adults fly or not, and if so when, sticky traps of the type commonly used for aphids, were erected in infested cabbage and charlock fields around Cambridge and maintained over two years. Although small numbers of *Ceuthorhynchus quadridens* Panz were caught from time to time, only two specimens of *C. pleurostigma* were trapped.

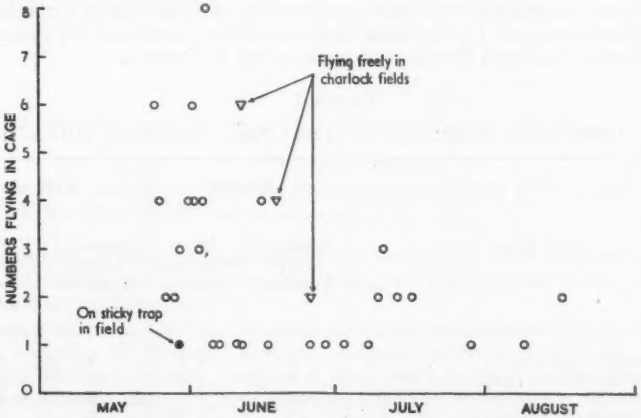



Fig. 2. Numbers of weevils observed flying during the summer months.

In a large outdoor cage in which forty adults of the gall weevil were confined for work on biological races, flight was observed in May in bright sunny weather. This gave evidence that the adults were capable of flight, and attempts were made to maintain records of the number flying in relation to conditions in the cage at two-hourly intervals during the day time. The cage was large enough to permit the

introduction of a psychrometer through a sleeve. The results are plotted in Figs. 2 and 3. Under these conditions weevils flew from May to August in bright, sunny weather and there was a suggestion that on days suitable for flight peaks occurred during the morning and afternoon, with a lull about midday. Flight of adults was also plotted against the percentage relative humidity and the dry bulb temperature (Fig. 4). Flight was confined within the limits of 63°F. and 82°F. dry bulb temperature and between 36 and 64 per cent relative humidity.

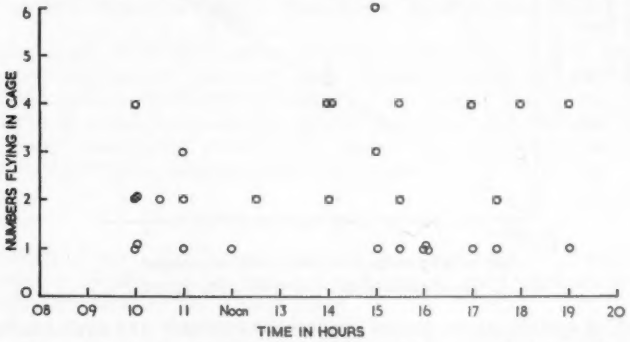



Fig. 3. Numbers of weevils observed flying in large cage during daytime.

## HOST PREFERENCE

Observations were made to ascertain the host preferences of adults feeding on the leaves of important crucifers. Forty adults of a summer brood bred from cabbage were released on various crucifers in a large cage, and the leaves were subsequently examined for damage. Each time, the leaves of two plants of each cruciferous species were examined. The outlines of the leaves, along with the damaged areas, were drawn on a tracing paper; then, with the help of a planimeter, the whole leaf area and the damaged area were determined and the percentage damaged area calculated. Results are summarized in Table 1.

TABLE 1

*Comparative Feeding by Adults on Cruciferous Leaves, 1951*

| Host Plant | June 15 | | June 26 | |
|---|---|---|---|---|
| | *Number of Leaves Examined* | *Mean Percentage Damaged Area* | *Number of Leaves Examined* | *Mean Percentage Damaged Area* |
| Turnip (*Brassica rapa* L.) | 7 | 6·6 | 5 | 8·5 |
| Brussels sprouts (*B. oleracea* L.) | 8 | 1·0 | 10 | 0·7 |
| Summer cabbage (*B. oleracea* L.) | 6 | 1·2 | 9 | 1·2 |
| January cabbage (*B. oleracea* L.) | 7 | 1·4 | 6 | 0·1 |
| Cauliflower (*B. oleracea* L.) | 6 | 1·5 | 7 | 1·1 |
| Swedes (*B. napus* L.) | 6 | 1·3 | 4 | 1·1 |
| White mustard (*Sinapis alba* L.) | 8 | 1·5 | 16 | 1·6 |
| Charlock (*Sinapis arvensis* L.) | 6 | 4·2 | 10 | 4·3 |

The results suggest that leaves of turnip (normally infested by the summer brood) and charlock (normally infested by the spring brood) are preferred to

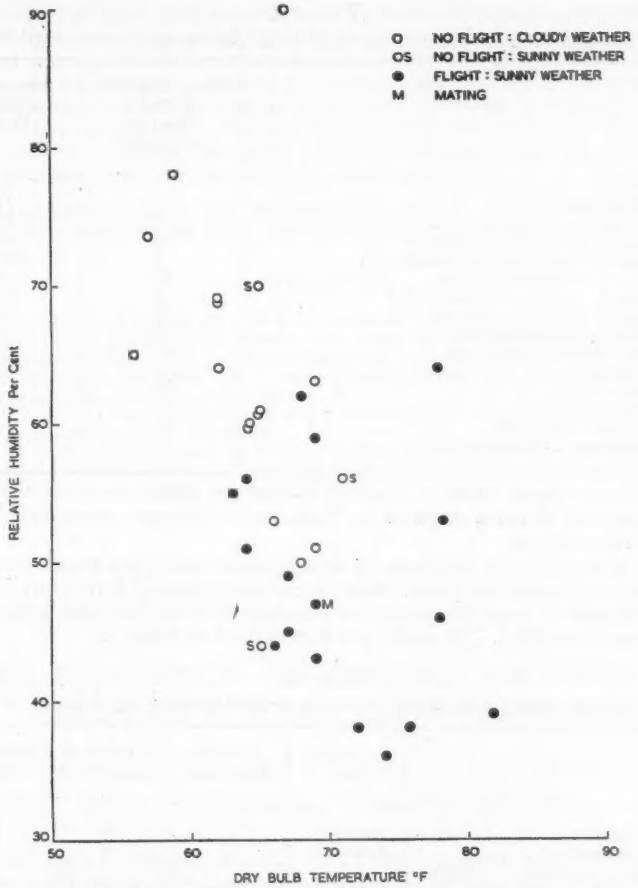



Fig. 4. The flight of adults of *Ceuthorhynchus pleurostigma* in relation to humidity and temperature conditions in the cage.

those of cabbage, Brussels sprouts, cauliflower, and swedes. This does not accord with Isaac's theory that there are two biological races corresponding to the summer and spring broods.

According to Isaac (1923a) the host plants of the summer brood are the different varieties of *Brassica oleracea*, namely, cabbage, cauliflower, kale, broccoli and Brussels sprouts; turnips, *B. rapa*, and swedes, *B. napus*, and those of the spring brood, charlock *Sinapis arvensis* alone.

A field trial in randomized blocks with four replications was therefore set up during summer at the time of oviposition by the summer brood. The field selected was one at Girtford (Bedfordshire) which had shown heavy infestation throughout the preceding winter. Various cruciferous seeds obtained from the Botanic Gardens at Kew and Cambridge were sown in rows 1 foot 6 inches long and 1 foot apart, there being only one row for each variety. Out of thirty-six species of plants which grew, fourteen were galled to varying degrees as shown in Table 2.

TABLE 2

*Cruciferous Plants Galled in a Field Trial During the Summer of 1951*

| | Total Number of Plants Open to Infestation | Percentage of Galled Plants |
|---|---|---|
| *Biscutella didyma* L. | 3 | 33 |
| *Brassica napus* L. (Swede) | 5 | 40 |
| *B. oleracea* L. (Early white broccoli) | 4 | 50 |
| *B. oleracea* L. (Autumn giant cauliflower) | 1 | 100 |
| *B. oleracea* L. (Brussels sprouts) | 17 | 6 |
| *B. oleracea* L. (January King cabbage) | 9 | 33 |
| *B. oleracea* L. (Summer cabbage) | 11 | 55 |
| *B. oleracea* L. (Drumhead savoy) | 8 | 38 |
| *B. rapa* L. (White stone turnip) | 20 | 25 |
| *Eruca sativa* Lam... | 5 | 20 |
| *Isatis gluaca* Willd | 22 | 5 |
| *Raphanus rostratus* DC | 16 | 13 |
| *Sinapis alba* L. (Charlock) | 27 | 4 |
| *Sinapis arvensis* L. (White Mustard) | 3 | 100 |

Besides the plants noted in Table 2, two others which served as hosts were noted, namely *Brassica oleracea* L., Kale, and *Coronopus squamatus* (Forsk.) Aschers, swinecress.

In the following year, a field survey of host plants among the cruciferous weeds and cultivated crops was made. Observations were made at fortnightly intervals during the period when the infestation was noticed in charlock and in new crops of cultivated crucifers. The results are summarized in Table 3.

TABLE 3

*Host Plants Among Cruciferae Grown in the Field During the Summer of 1952*

| Species | Examined in | Number Examined | Number of Galled Plants | Percentage Galled |
|---|---|---|---|---|
| *Sinapis arvensis* L. | June–Aug. | 142 | 90 | 63 |
| *Brassica campestris* L. | June–July | 42 | 6 | 14 |
| *Coronopus squamatus* (Forsk.) Aschers (Swinecress) | June–July | 38 | 2 | 5 |
| Various cultivated crucifers | July–Sept. | 216 | 20 | 9 |

The following species were examined, mostly in June, with negative results: *Sisymbrium officinale* (L) Scop. (hedge mustard) 143 plants; *Lepidium draba* L (hoary cress) 26 plants; *Capsella bursapastoris* L (shepherd's purse) 264 plants; *Armoracia lapathifolia* Gilib. (horse-radish) 21 plants; *Thlaspi arvense* L. (penny-cress) 14 plants; *Erysimum cheiranthoides* (L) (treacle mustard) 3 plants; and *Raphanus raphanistrum* L (wild radish) 8 plants.

The only weeds noted as host plants for *C. pleurostigma* were *Sinapis arvensis*, *Brassica campestris*, and *Coronopus squamatus*, the last two showing infestation at the same time as charlock. The infestation in a *Brassica* sp. exactly at the same time as charlock is another observation which does not accord with Isaac's theory of biological races.

SUMMARY

Experiments on the formation of galls suggested that initiation did not take place during the egg stage of the weevil, but started as soon as the egg hatched

into a first instar larva. Gall size progressively increased with the size of the larval instar. Aphid sticky traps failed to catch many weevils in flight but evidence was obtained that weevils are capable of flight in bright sunshine, especially in early summer. An experiment on feeding preferences suggested that turnips and charlock leaves were preferred to those of common cultivated brassicas. In a field survey of host plants among the cruciferous weeds and cultivated crops, a few new hosts were recorded, including *Coronopus squamatus* (Forsk) Ascher, on which galls are formed at the same time as on charlock.

I wish to thank Mr. F. G. W. Jones for help with the script, Mr. K. P. Humphries for lending his insect sticky traps, and Mr. B. W. Twinn for helping in the survey work in fields.

REFERENCES

IMMS, A. D. (1947). *A General Text Book of Entomology* (6th Ed.). Methuen, London.
ISAAC, P. V. (1923a). The Turnip Gall Weevil, *Ceuthorrhynchus pleurostigma*, Marsh (*Coleoptera, Curculionidae*). Part I. Life-history and Bionomics. *Ann. appl. Biol.*, **10**, 151–70.
ISAAC, P. V. (1923b). The Turnip Gall Weevil, *Ceuthorryhnchus pleurostigma*, Marsh. Part II. Larval anatomy. *Ann. appl. Biol.*, **10**, 171–89.
ISAAC, P. V. (1923c). The Turnip Gall Weevil, *Ceuthorrhynchus pleurostigma*, Marsh. Part III. Control. *Ann. appl. Biol.*, **10**, 190–3.
MADLE, H. (1935). [Observations on *Ceuthorrhynchus pleurostigma* and *C. quadridens* in the Vegetable-growing District of Zittau in Summer 1934]. *Z. PflKrankh. Stuttgart*, **45**, 478–98. Cited in *Rev. appl. Ent.* Ser. A, **23**, 704–5.

# THE EFFICIENCY OF CERTAIN GRASSES AS HOSTS OF CEREAL ROOT EELWORM

*by* J. J. HESLING

*Rothamsted Experimental Station, Harpenden, Herts*

THE host range of *Heterodera major* (O. Schmidt) appears to be confined to the *Gramineae* (Winslow, 1954), within which are many crop species and varieties of grasses. A knowledge of the efficiency of these grasses as hosts of cereal root eelworm is important, for the common practice of grassing down infested arable land would be of little use if the grasses themselves were a crop which maintained a serious reservoir of eelworm infestation. An experiment was set up in 1955, using four species of grass sown in soil containing different infestations of *Heterodera major*, to investigate this matter.

The species used were chosen because they were grasses commonly used in British agriculture: Italian ryegrass, *Lolium italicum*, S.22; perennial ryegrass, *Lolium perenne*, S.23; cocksfoot, *Dactylis glomerata*, S.143; and timothy, *Phleum pratense*, S.48. Each grass was sown in flower pots of 5½-in. maximum top diameter each containing approximately 1010 g. (770 c.c.) of sandy soil. The soil was examined before use and no eelworm cysts were found in it. Five infestation levels were prepared by adding a known number of *H. major* cysts to each pot to give four replications of each level; uninfested soil was used for a control series. The cysts used as inoculum were extracted from moist soil by an elutriation technique (Hesling, 1956); they were all large, having been selected from the fraction of the population which remained on a 30 mesh/in. sieve; each cyst was

examined for fullness and full cysts only were used in the experiment, at the following inoculum levels:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cysts per pot .. | .. | .. | 0 | 1 | 2 | 4 | 8 | 16 |
| Eggs per pot .. | .. | .. | 0 | 448 | 896 | 1792 | 3584 | 7168 |
| Eggs per g soil | .. | .. | 0 | 0·4 | 0·9 | 1·8 | 3·5 | 7·1 |

The pots of soil were inoculated with cysts on March 26, 1955, and were then placed in random order in a gravel plunge. The grasses were sown in the pots on April 7, 1955. In October 1955, the pots were removed from the plunge and their contents were dried. All the soil from each pot was examined for eelworm cysts, which were collected and counted; new and old cysts could not be separated, but the mean egg content of the cysts in each pot was estimated.

The mean final population produced from each inoculum level by each grass is shown in Fig. 1, the results of a similar experiment using oats grown under similar conditions (Hesling, 1957) are added for comparison. The results for timothy are not shown, as only twelve new cysts were produced in all the twenty pots growing this grass. Timothy is clearly a very poor host. The three other grasses increased the cereal root eelworm population, but the increase was far less than that on oats grown with similar inocula under similar conditions. The "cyst efficiency" of the grasses is low (Fig. 2), and suggests that they are relatively poor cereal root eelworm hosts. There is no evidence of a fall in "cyst efficiency" with increase of inoculum, as has been found with cereals (Hesling, 1957), but this effect may be masked by the high variability associated with the low inocula used. Thus, over the range of inocula tested the eelworm multiplication factor showed little change. Analysis of the final numbers of eggs per pot did not suggest any significant differences in the host efficiency of the grasses.

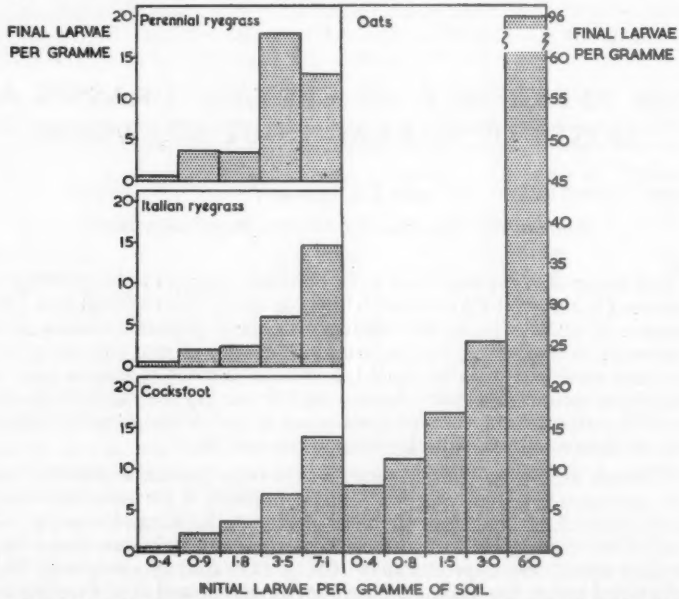
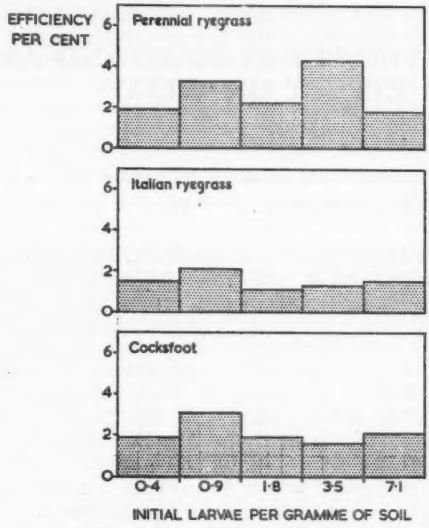



Fig. 1. Final population of *Heterodera major* (larvae per gramme of soil) from different initial infestation levels by grasses and oats. Each value is the mean of four replicates.

In these pot experiments all the grasses except timothy were capable of increasing the eelworm population, but the multiplication factor was small. It




Cyst efficiency = $\frac{\text{Number of new cysts produced}}{\text{Number of potential cysts}} \times 100$

Assuming a sex ratio of unity, the number of potential cysts is half the number of original larvae per plot (Hesling, 1957).

Fig. 2. The "cyst efficiency" of three grass hosts of *Heterodera major*.

has been shown that pot experiments tend to produce increases of *H. major* which are greater than those found in the field (Hesling, 1958); a reason for this may be that the restriction of eelworm and plant roots within the pot provides more opportunity for the eelworm larvae to invade. In the field, *H. major* populations decline under fallow and non-host crops to about 40 per cent of their original value in one year; under certain grasses and leys there may also be a similar fall in the eelworm population (Hesling, 1958)—further evidence that grasses are relatively poor hosts.

Low "cyst efficiency" in cereals is often associated with heavy eelworm invasion and crop damage. Examination (after staining) of roots of grasses and cereals from heavily infested soil shows that the number of larvae invading grasses is small, while oat roots are heavily attacked. Thus it seems that the low "cyst efficiency" of grasses is a result of scanty larval invasion, and an indication of true "resistance". The low efficiency of timothy shown in this experiment confirms the results of Bovien (1953) who found also that perennial and Italian ryegrass and cocksfoot were among the most highly infested grasses which he examined. Unless it is shown that there are biotypes of *H. major*, of which cereals and grasses are equally highly efficient hosts, it seems safe to advise grassing down infested fields—a procedure which Bovien claims to have found suitable. The decline of the eelworm population may be slower beneath a host grass, but if the grass is followed by two years of non-host cropping a substantial reduction in eelworm population should reasonably be expected.

## REFERENCES

BOVIEN, P. (1953). Om havreålen (*Heterodera major*) og resultaterne af nogle forsøg på smittet jord. *Tiddskr. Planteavl.* **56**, 581–91.

HESLING, J. J. (1956). Some Observations on *Heterodera major*. *Nematologica*, **1**, 56–63.

HESLING, J. J. (1957). *Heterodera major* O. Schmidt 1930 on Cereals—a Population Study. *Nematologica*, **2**, 285–299.

HESLING, J. J. (1958). *Heterodera major* O. Schmidt 1930—Population Changes in the Field and in Pots of Fallow Soil. *Nematologica* (in the press).

WINSLOW, R. D. (1954). Provisional lists of host plants of some root eelworms (*Heterodera* spp.). *Ann. appl. Biol.*, **41**, 591–605.

# SOME TURNIP VIRUSES IN SCOTLAND AND THEIR EFFECT ON YIELD

*by* R. M. LISTER

*Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee*

VIRUSES transmissible by flea-beetles have been found infecting swede and turnip crops in several parts of England and in Scotland (Markham and Smith, 1949, Broadbent and Heathcote, 1958). Observations over several years indicate that such viruses are widespread, and sometimes prevalent, in eastern Scotland where both swede and turnip are widely grown as fodder crops. Croxall, Gwynne and Broadbent (1953) described outbreaks of a severe disease of winter cauliflower, savoy, cabbage and Brussels sprout in the Northumberland–Durham area, caused by a strain of turnip yellow mosaic virus, but the effects of strains of this and other similar viruses on the yield of turnip have not been studied. This paper records the isolation of strains of turnip yellow mosaic, turnip crinkle and turnip rosette viruses from diseased turnips and swedes in eastern Scotland, and their effects on the yield of yellow turnips in a field experiment.

## ISOLATION AND IDENTIFICATION OF VIRUSES

In the autumn of 1956, fields of yellow turnip, *Brassica rapa* L., in Angus and Perthshire were seen in which practically all plants had yellow, crinkled leaves and were moderately or severely stunted. All the diseased turnips sampled proved to be infected with both turnip crinkle and turnip yellow mosaic viruses, which were transmitted together mechanically and by flea-beetles (*Phyllotreta* sp.) to turnip seedlings. These viruses were also isolated from apparently healthy swedes (*Brassica napus* L.), growing alongside infected yellow turnips. Turnip crinkle virus was easily separated from turnip yellow mosaic virus because it infects and produces local lesions in inoculated leaves of *Chenopodium amaranticolor* Coste & Reyn, whereas turnip yellow mosaic virus does not (Broadbent and Heathcote, 1958). The virus was also isolated by inoculating sap on to the leaves of *Nicotiana tabacum* L., *Nicotiana rustica* L. and *Cucumis sativus* L., for, unlike turnip yellow mosaic virus, it was found to infect these plants, multiplying locally in inoculated leaves and producing chlorotic and necrotic local lesions in the last two.

No differential host for turnip yellow mosaic virus was found, but the virus was isolated from the sap of infected plants after precipitating turnip crinkle virus with excess of a specific antiserum kindly supplied by Dr. J. W. Blencowe of Rothamsted Experimental Station. When clarified sap from infected turnip plants was mixed with excess of the turnip crinkle antiserum and incubated overnight at 37°C, it no longer produced lesions when rubbed on *C. amaranticolor*, but readily infected turnip and Chinese cabbage (*Brassica pekinensis* Rupr.), producing only the bright yellow mottle symptoms typical of turnip yellow mosaic infection. Turnip and Chinese cabbage plants, inoculated with mixtures of the two viruses thus isolated, developed symptoms indistinguishable from those in comparable plants inoculated with sap from infected turnip or swede plants from the field.

In 1956, a strain of turnip rosette virus was isolated from swedes growing near Dunkeld, Perthshire; the plants were stunted and had patches of necrosis on the leaf-petioles and veins. Swedes and yellow turnips infected with this

virus were also found near Invergowrie in 1957. The symptoms of the Dunkeld strain of turnip rosette virus in turnip and Chinese cabbage varied, and included the development of small dark brown lesions in inoculated leaves, and systemic veinal necrosis with leaf puckering and distortion. Infected plants were stunted, and sometimes had elongated oval necrotic areas along the leaf-petioles. The effects were not quite as severe as those in turnips infected with a strain of turnip rosette virus originally obtained from Edzell, Kincardineshire, supplied by Dr. L. Broadbent of Rothamsted Experimental Station.

When fresh sap from turnips infected with each of the three viruses was diluted with water, mixed with the abrasive "Celite" and inoculated to the leaves of turnip and Chinese cabbage, infections were occasionally obtained at dilutions of $10^{-6}$. Experiments in which sap from infected turnip and Chinese cabbage was heated to different temperatures for ten minutes and then rubbed on the leaves of suitable host plants, showed that the turnip crinkle virus was inactivated by heating to 85°C but not 80°C; the turnip yellow mosaic virus by heating to 75°C but not 70°C and the Dunkeld isolate of turnip rosette virus by heating to 75°C but not 70°C. Clarified saps from turnip plants infected with the turnip crinkle, turnip yellow mosaic and turnip rosette viruses respectively, each precipitated specifically with authentic antisera supplied by Dr. J. W. Blencowe. No plant protection tests were made with the turnip crinkle or turnip yellow mosaic viruses, but leaves of turnip plants systemically infected with the Edzell strain of turnip rosette virus developed many local lesions when inoculated with the Dunkeld isolate. This lack of cross-protection between different strains of turnip viruses has previously been reported for turnip yellow mosaic and turnip crinkle viruses (Broadbent and Heathcote, 1958).

## EFFECTS OF VIRUS INFECTION ON YIELD

In glasshouse tests, Chinese cabbage and turnip plants infected with any one of the three viruses were rather stunted. Infection with any of the three viruses did not prevent subsequent infection with the others and their combined effects were cumulative. The results of infectivity tests with plant saps, using *C. amaranticolor* as a local lesion assay host, suggested that the presence of turnip yellow mosaic virus did not affect the multiplication of turnip crinkle virus. In the field the leaves of yellow turnips containing both turnip crinkle and turnip yellow mosaic viruses were often extremely small so that, in many plants whose older leaves had withered, only a small tuft of leaves remained. However, the "bulb" of such plants was often of normal size.

A field trial comparing the root yield of yellow turnips infected with each of the three viruses, singly and in all combinations, with that of healthy controls, was made in 1957 on one acre of the variety Bruce. Of the four commonly grown varieties investigated (Bruce, Wallace, Balmoral and Aberdeen Yellow) this one was selected because the symptoms it developed in the glasshouse, when infected with the three viruses, were intermediate in severity. A randomized block design with six replications was used for the field trial, and the sub-blocks allotted to the eight treatments were split so that the viruses could be inoculated at two different times during the season. As far as possible, about twenty-five plants were included in each experimental plot unit. Since it has been suggested that turnip yellow mosaic and turnip crinkle viruses may spread by leaf contact during wind disturbances (Broadbent and Heathcote, 1958), each plot was isolated by the removal of plants around its perimeter, and so that any virus spread could be observed, plots were further separated by several guard rows. Seed that had been treated with insecticide was used, and, until late in the season, the whole area was sprayed with an insecticide at intervals. No flea-beetles or flea-beetle damage were observed in the area during the experiment. Fewer than ten plants which had not been inoculated had virus symptoms at harvest, and there was no evidence of any virus spread other than this during the experiment.

The final singling of plants and the marking out of plots was completed in early June, and the first inoculations were made on June 24 and 25, when the plants had about 6–8 leaves and no root swelling. Inoculations were done by quickly rubbing cotton wool pads, soaked in a mixture of "Celite" and the sap of infected turnip plants, on to part of one leaf of each plant. Symptoms of infection were first seen on new leaves early in July, those of turnip yellow mosaic being the most obvious. The second series of inoculations was made on August 1: at this time the plants were growing quickly and the roots beginning to swell. Symptoms were first seen on plants in this series on August 14. The effects of infection on the leaves of the plants became progressively more severe during the season, particularly in plants inoculated with both turnip crinkle and turnip yellow mosaic viruses. At the end of September about 85 per cent of plants inoculated with turnip crinkle virus and about 65 per cent of those inoculated with turnip yellow mosaic virus showed symptoms, but less than 50 per cent of those inoculated with turnip rosette virus did so. This diagnosis was checked for some plots by sap-inoculation to suitable test plants in the glasshouse.

The plants were harvested on October 10, "topped" and "tailed" in the usual way, and the roots from each plot were counted, bagged and weighed. There was no significant difference between the mean root weights for these plots in which the turnips had been inoculated and the healthy control plots. Using a cork borer, root samples were taken from all turnips in the control plots and from those inoculated with a mixture of turnip yellow mosaic and turnip crinkle viruses. These were weighed, oven-dried and weighed again to determine their dry matter content. There was no significant difference in the percentage dry matter between inoculated and healthy plants.

Rather surprisingly, the results of this experiment show that the strains of turnip crinkle and turnip yellow mosaic viruses used to infect the plants did not have much effect on their root development, despite the drastic effects of infection on the foliage. As only a relatively small proportion of plants became infected with the turnip rosette virus, no definite conclusions can be drawn about the effects of this virus. Young turnip seedlings inoculated in the glasshouse with turnip crinkle virus mixed with either of the other two viruses used in this experiment were sometimes killed, usually by secondary fungal diseases, but older plants rarely were. No investigation was made in the field of the reactions of very young seedlings to virus infection, and it is possible that plants infected by flea-beetles soon after germination may be killed or their root development severely reduced.

## SUMMARY

Strains of turnip yellow mosaic, turnip crinkle and turnip rosette viruses were isolated from yellow turnip and swede plants in Angus and Perthshire in 1956. In replicated field trials conducted in 1957, inoculation of yellow turnips (variety Bruce) at the 6–8 leaf stage with the strains of turnip crinkle and turnip yellow mosaic viruses had little effect on the yield of roots, despite drastic effects on the foliage. Glasshouse tests indicated, however, that earlier infection by flea-beetles may kill or severely damage turnip seedlings.

My thanks are due to those mentioned in the text; to Dr. C. H. Cadman for much helpful advice given in the course of this work and to Miss Patricia Duncan for technical assistance.

## REFERENCES

BROADBENT, L. and HEATHCOTE, G. D. (1958). To be published.

CROXALL, H. E., GWYNNE, D. C. and BROADBENT, L. (1953). Turnip Yellow Mosaic in Broccoli. *Plant Pathology*, **2**, 122–3.

MARKHAM, ROY and SMITH, KENNETH M. (1949). Studies on the Virus of Turnip Yellow Mosaic. *Parasitology*, **39**, 330–42.

# PEA MIDGE IN YORKSHIRE AND LANCASHIRE

*by* W. J. BEVAN *and* G. MURDOCH
*National Agricultural Advisory Service, Leeds*

IN the Yorkshire and Lancashire Region about 17,000 acres of peas are now grown annually for freezing, canning and the green pea market and about 8,000 acres for harvesting dry. Pea midge, *Contarinia pisi* Winn., has been recorded by the advisory entomologists in this region for many years, and from time to time it has caused severe damage. In 1928, 1930 and 1931 Miles recorded destruction of terminal shoots and flowers in Lancashire. Heavy attacks in the Doncaster, South Milford and Selby areas of Yorkshire in the years 1935–38, and again in 1945 and 1947, were recorded by Thompson. In the latter year, and in 1952, attacks were also reported in Lancashire.

Our attention was drawn to the pest in 1954 whilst visiting pea fields, when larvae were found in the terminal shoots in late July. Further investigation showed that many crops in the West Riding were affected. In 1955, attacks were widespread and infestations were heavy, but losses caused by the pest were generally low; we inspected 255 acres of April–May sowings and found only 45 acres, sown towards the end of May, in which the yield loss was as high as 40 per cent. In 1956, most pea crops in the East and West Riding were severely attacked; we inspected 615 acres of April–May sowings and found 315 acres with 40–70 per cent yield loss. In 1957, attacks were heavy in all pea growing areas of Yorkshire and Lancashire and losses were often severe: of 1,175 acres of April–May sowings inspected, 480 acres suffered 40–70 per cent loss.

It was evident at an early stage that heavy attack was not always accompanied by serious loss in yield, and investigations have been in progress since 1955 to determine some of the factors influencing the severity of midge attack on the pea crop, the resultant damage and its effect on yield.

## ADULT MIDGE ACTIVITY

These investigations have indicated that the adults respond to temperature and humidity changes. In hot sultry weather activity is high and may remain so even under slightly moist conditions provided the air is warm. Cool and wet conditions are not favourable, but there is a quick response to marked increases in temperature which may occur in such periods. Thus large numbers of eggs may be laid in cool wet seasons provided conditions, even for relatively short periods, are favourable. In very windy conditions the adults tend to remain in the sheltered areas of the pea fields.

In 1957, the first midges were recorded in Yorkshire in late June. Barnes (1927) recorded them as early as mid June in the South of England. Adult emergence and activity in Yorkshire has varied from year to year and the data for the years 1954–57 are presented in Table 1.

The peak of the first flight in 1957 was apparently reached within about two days of the initial emergence, whereas in the two previous years the peak was not reached until about fourteen to eighteen days respectively after the beginning of the flight. Confirmation of midge prevalence and activity was obtained by observing the extent of egg laying and subsequent larval infestations in the crop. The initial infestations in 1955 and 1956 were very light, only odd plants in crops being affected.

In each of the three years small numbers of adults could be found when conditions were favourable following the period of peak activity. In very late-sown pea crops, shoots infested with young larvae were found during August. These infestations were relatively light compared with those from the attacks earlier in the season. It would seem that the late flight of adults, occurring about four weeks after the main one, is of much less significance. Studies on pupal populations in the soil (Bevan and Uncles, 1958) showed that the adult potential for the first flight of 1957 in Yorkshire, far exceeded that for the late one.

TABLE 1

*Pea Midge Activity over the Years 1954–57*

| Year | Adult Activity | | | Larval Infestations | | |
|---|---|---|---|---|---|---|
| | First Flight | | Second Flight | First Generation | | Second Generation |
| | *Earliest* | *Peak* | | *Earliest* | *Peak* | |
| 1954 .. | | July 20–25 | Aug 21 | | July 31 | Aug 29 |
| 1955 .. | June 29 | July 10–14 | Aug 13 | July 9 | July 18 | Aug 18 |
| 1956 .. | June 30 | July 14–19 | Aug 20 | July 7 | July 23 | Aug 26 |
| 1957 .. | June 27 | June 28–July 2 | July 30 | July 8 | July 8 | Aug 6 |

## OVIPOSITION

The majority of adult midges found in pea crops were females, and were usually within the terminal shoots of the plants. The presence of females and eggs within the shoots soon after adult emergence from soils of nearby fields cropped with peas in the previous year confirms that emergence, mating, dispersal and oviposition may all occur in a short space of time (see Barnes, 1946).

The eggs are white and translucent with a tail-like appendage at one end; they are approximately $\frac{1}{4} \times \frac{1}{10}$ mm., and are just visible to the naked eye. They are laid in batches, counts indicated an average of 28 per batch, the range being 7 to 54. The highest number of eggs found in any one flower was 105. In the laboratory eggs hatched in about five days and the larvae were fully fed in ten to twelve days.

Pea crops at or near the flowering stage, even those within about seven days of flowering where the flower buds are still enclosed within the terminal leaflets, are used for oviposition. The precise site appears to depend on the stage of development of the flower. In young shoots, well before flowering, eggs were recovered from the inner surfaces of the leaflets and flower buds. In the latter, where the petals had not developed sufficiently to enclose the stamens, eggs were deposited on top of the anthers and on the inner surfaces of the calyx. In buds where the petals enclosed the stamens and were in turn still enclosed by the calyx, eggs were found deposited between the calyx and corolla. In crops already flowering, eggs were found within the flowers, on the outside of the calyx and on the terminal leaflets. When eggs were readily found in these last two sites on several plants in a crop, the overall infestation tended to be very heavy.

## DAMAGE

Damage of economic importance to field peas is centred on the terminal shoots, developing flowers and the very early stages of developing pods. A typical symptom of attack is the clustered appearance of the terminal shoot.

Damaged flowers are swollen and lumpy, with the calyx irregularly coloured dark and light green. These symptoms develop quickly after the larvae start feeding, and the damaged shoot and flower tissues are soon invaded by secondary agents. By the time the larvae are fully fed the tissues are often reduced to a rotting mass, particularly in wet weather. Pods were examined in many infested crops but no larvae were found within them.

Green peas are normally sown between early March and late May. Harvesting peas are drilled as soon as soil conditions permit. The main attacks may occur any time from late June to mid July, the loss likely to result depending mainly on the stage of flower set or the numbers of pods present at the time.

In practice, the earliest sowings may avoid infestation; the early main crops have often started to pod by the end of June, and attack merely prevents further flowering, thus allowing the crop to mature more uniformly and yield heavily. Midseason crops tend to be heavily infested, but most may yield fairly well while some suffer losses. The late main crop and late sowings tend to be very heavily infested at or before the beginning of flowering and suffer heavy losses; some of these crops have yielded as little as 6 cwt per acre of vined peas, and many are ploughed in. The yield data shown in Table 2 were obtained from farmers at two vining centres which deal with peas from eleven farms. The acreages involved varied from 700–800 annually.

TABLE 2

*Some Yields from Pea Crops Infested by Midge*

| Year | Yield of Vined Peas (cwt per acre) | | | |
|---|---|---|---|---|
| | *Early April Sowing* | *Mid–Late April Sowing* | *Early–Mid May Sowing* | *Late May Sowing* |
| 1955 .. | 52 | 40 | 22 | 18 |
| 1956 .. | 38 | 27 | 17 | 12 |
| 1957 .. | 47 | 37 | 19 | 10 |

It is not easy to separate loss directly attributable to midge from losses due to unfavourable weather and growth conditions. Late drilled crops usually have a higher plant population per acre from comparable seed rates, but the yield per plant drops; when midge is present at the critical time it is almost certainly the major factor in such yield reduction. Trends similar to those shown in Table 2 were obtained for peas picked green for market, but ruling prices often influence the choice between picking or ploughing-in affected crops. Dry harvesting pea crops may be heavily infested but are usually well podded at the time of attack, and thus do not normally suffer serious loss due to this pest.

Soil type and, more particularly, weather conditions during the growing season influence the time interval from sowing to harvesting. Cold wet conditions at any time cause slow growth. Their effect at flowering and podding time can be most marked, the flowers tending to be produced over a prolonged period, the growers saying the crop never "finishes". Conversely the occurrence of hot weather at flowering and podding time tends to shorten the period of development. These phenomena were seen in contrast in 1955 and 1956 and had a marked effect on the extent to which midge damage affected loss in yield, and are illustrated in Table 2. Thus in a cool wet season like 1956, pea yields may be expected to be lower and loss from midge attack coupled with that caused by secondary agents is likely to be more severe.

SUMMARY

*Contarinia pisi* Winn. as a pest of peas in Yorkshire and Lancashire is discussed with particular reference to the years 1954–57. The main flight occurred at any time from late June to the third week of July. The initial flight was the main one as in 1957, or the forerunner of one occurring up to eighteen days or so later as in 1955 and 1956. The eggs were laid in batches in the terminal shoots and flowers; a mean number of 28 per batch was recorded. The highest number of eggs found in any one flower was 105. Larval infestations were confined to the terminal shoots and flowers, but none was found within the pods in field crops. Most maincrop sowings were fairly heavily infested. Late midseason and late sowings tended to suffer the heaviest losses in yield and these were of considerable economic importance to the pea growing industry. Yields tended to be lower in cool and wet seasons, and losses from midge attacks of similar intensities tended to be higher than when conditions were more favourable for crop growth.

Thanks are due to Mr. H. W. Thompson and Dr. H. F. Barnes for encouragement and helpful criticism; also to district officers and many farmers in Yorkshire and Lancashire for their co-operation.

REFERENCES

BARNES, H. F. (1927). New Damage to Peas by the Pea Midge. *J. Minist. Agric.*, **34**, 159–61.

BARNES, H. F. (1946). *Gall Midges of Economic Importance. Vol. 1: Gall Midges of Root and Vegetable Crops.* Crosby Lockwood, London.

BEVAN, W. J. and UNCLES, J. J. (1958). Studies on Soil Populations of *Contarinia pisi* Winn. in Yorkshire and Lancashire in 1957. *Ann. appl. Biol.* (in the press).

# OBSERVATIONS ON A RACE OF *DITYLENCHUS DIPSACI* ATTACKING ANNUAL ASTER AND SWEET SULTAN

*by* E. B. BROWN

*National Agricultural Advisory Service, Cambridge*

IN 1955, a severe attack of stem eelworm *Ditylenchus dipsaci* (Kühn) Filipjev, on annual aster, *Callistephus chinensis* Nees, and sweet sultan, *Centaurea moschata* L., occurred on a field in Suffolk. This field had been planted with flower crops for the first time in 1954, and for many years previously had grown only sugar beet and barley. By July, when the field was first visited, large bare patches were present in the planting of asters, and an area where the crop had failed completely had already been ploughed up. The affected sweet sultans were growing on a part of the field where there had been asters in the previous year, also probably damaged by stem eelworm.

The infested aster plants were stunted, with swollen and distorted stems and petioles (Plate 2). Very large numbers of all stages of *D. dipsaci* were present in the main stems and there were considerable numbers in the petioles. The picking of the sweet sultan crop had been completed when it was first seen. There were no bare patches in this crop and it seemed that no plants had been killed. The main symptom here was swelling and twisting of the flower stem, particularly just below the flower head (Plate III, 1). Nematodes were very numerous in these swellings, and had also invaded the receptacles in large numbers. In some flower heads nematodes were present among the developing ovules, and if the seed had

been harvested there is no doubt that it would have been infested. On another part of the field a similar type of damage was seen on a flower stem of pyrethrum, *Chrysanthemum coccineum* Willd. On this plant both *D. dipsaci* and *Aphelenchoides ritzema-bosi* (Schwartz) were numerous in the swelling below the flower head, and the latter species was responsible for interveinal necrosis on the leaves.

No trouble had been noticed in any of the previous crops of sugar beet and barley. Part of the field again grew sugar beet in 1956 but no evidence of stem eelworm infestation could be found. The possibility of seedborne infestation in the asters was therefore considered. However, several varieties of asters growing on this field were attacked, and the same varieties raised from the same seed, but growing on a nearby field, remained healthy. It was therefore concluded that the nematode must have been already present in the soil (sandy loam), and it may have been introduced in farmyard manure containing oat straw which was applied to the field several years previously.

A small replicated host-range trial was done on the field in 1956, the plants tested being: oats, sugar beet, onions, field beans *Vicia faba* L., carrots, asters and annual phlox, *Phlox drummondii* Hook. Stem eelworm damage, varying in extent, occurred on all these plants except the carrots. The oats suffered a severe attack of frit fly, *Oscinella frit* L., but a fairly heavy eelworm attack developed on some of the later tillers. The onions, although severely damaged by larvae of the onion fly, *Delia antiqua* Meig., were also heavily attacked by stem eelworm. The phlox plants also suffered very severe eelworm damage, a large number of them being killed. The stems were swollen, puffy and distorted and most of the leaves were pale yellow due to the nematodes spreading out into the mesophyll from the leaf bases and midveins. The young field beans remained free from symptoms but, as they matured, brownish-black lesions developed particularly at the base and also high up on the stems. These symptoms are similar to those described on field beans by Goodey and Brown (*J. Helminth.*, 1956, **29**, 187–92) in a host-range trial carried out on a field on which carrots had been severely damaged. In the beans from the present trial nematodes were common in the pith and also occurred in a number of the pod stalks. The eelworm attack in the plants so far mentioned was very severe, eggs, larvae and adults of *D. dipsaci* being extremely numerous. The attack on the sugar beet was very slight, the only evidence of breeding being a few adults and eggs in two petioles.

The aster plants in this trial, in contrast to the previous year, were only slightly damaged, the only symptom being of a previously unrecorded type for *D. dipsaci*. This had occurred to a very slight extent the previous year and was an interveinal necrosis on the leaves, similar to that caused by *Aphelenchoides ritzema-bosi* (Plate III, 2). This type of injury has also been found by J. B. Goodey (*in lit.*) on the leaves of *Anemone hepatica* L.

During the course of these investigations a few weeds were also found to be infested on the field. Slight damage was seen on sow thistle, *Sonchus arvensis* L., and white campion, *Lychnis alba* Mill., and severe damage to fool's parsley, *Aethusa cynapium* L.

This is the first published record of damage by *D. dipsaci* to annual aster and sweet sultan in this country. Annual aster has been recorded as a host in the United States of America (*Plant Dis. Reptr. Suppl.*, 119, 1940, 275) but the attack on sweet sultan is a new host record, although other species of *Centaurea* have been recorded as hosts.

It is thought that the race of *D. dipsaci* in this field is the one which occurs very commonly in Great Britain, attacking a wide range of crops including oats, onions, field beans, parsnips and rhubarb (Goodey, T., *J. Helminth.*, 1947, **22**, 1–12).

Thanks are due to Mr. W. E. Dant for the photographs and to Mr. R. W. Rennison who reported the trouble in the field.

# NEW OR UNCOMMON PLANT DISEASES AND PESTS

**Mushrooms damaged by Tarsonemid Mites.** Damage to mushrooms by Tarsonemid mites was noted on a farm in Kent in August 1956, and this is believed to be the first British record. The mites were identified as *Tarsonemus* sp. by Mrs. A. M. Hughes. Occasional mushrooms scattered throughout crops in several houses were affected, the bases of the stipes being brown and largely devoid of mycelial attachments, similar in appearance to damage attributed to *Linopodes antennæpes* Banks (Plate I, 2). The mites were swarming in large numbers over the brown areas, and in a few cases the entire mushroom was brown. The compost had been pasteurized at 130–140°F. before spawning, and was cased with a 50 : 50 mixture of chalk and sphagnum peat. The beds had been treated with nicotine, diazinon, and malathion aerosols, and derris/pyrethrum dusts, with apparently little effect on the mites. The nearly related mites known as "red-pepper mites" including *Pygmephorus tarsalis* Hirst, have so far not been recorded as damaging mushrooms in Britain.

B. D. MORETON

**Powdery Mildew on Eucalyptus.** In July 1957, a batch of 500 bought-in seedlings of *Eucalyptus perrineana* and 300 of *E. gunnii* on a nursery at Goudhurst, Kent became severely affected by a species of *Oidium*. The temperatures in the glasshouse had been unusually high. Applications of dinitrocaprylphenyl crotonate (25 per cent wettable powder with wetter) gave good control. Later in April 1958 a similar powdery mildew was found on a nursery in the Wirral, Cheshire on seedlings of *E. perrineana* grown from seed the previous autumn. The conidia from the Kent material measured 24–30 × 15–18$\mu$ (mean 27 × 15$\mu$): those from Cheshire were slightly smaller. No perithecia were present on either lot of plants. There are no previous records of a powdery mildew on eucalyptus in Great Britain. An *Oidium* sp. with similar spores has been recorded by Grasso (*Nuovo G. bot. ital.* **55,** 1948, 581–4) from Italy. *Oidium eucalypsti* Rostr. was noted from Denmark (Rostrup, *Plantepatologi*, 1902, 436) and an *Oidium* sp. has been reported from Brazil (Stevenson, *Foreign Plant Diseases*, 1926, 70).

H. H. GLASSCOCK and W. R. ROSSER

## NEW EELWORM HOST RECORDS

***Heterodera cacti* Filipjev and Sch. Stekhoven,** the cactus root eelworm, was found on *Mammillaria confusa* Orcutt (two plants), *Trichocereus spachianus* Riccob., and a species of *Gymnocalycium* (probably *G. multiflorum* Britton and Rose) in 1957. The four plants were a sample from about 200 intended for export.

J. F. SOUTHEY

***Aphelenchoides ritzema-bosi* (Schwartz),** the chrysanthemum eelworm (det. J. B. Goodey) was recorded on *Buddlea variabilis* Hemsl. in 1955 on one of 100 small nursery plants grown in pots in Kent. Affected leaves were blotched with yellow, later turning brown and dying; some of the shoots on the branches were wholly brown.

B. D. MORETON

***Aphelenchoides fragariae*.** About 1 per cent of 2,000 pot plants of *Zebrina pendula* Schnizl. (tradescantia) in an East Sussex nursery in May 1956 were showing a thickening of the leaves. From the affected leaves eelworms resembling *A. fragariae* (Ritzema Bos) Christie were recovered.

B. D. MORETON



(74463) Wt. 25 K. 9 11/58 Hw.